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# TRANSACTIONS

OF THE

# Illinois State Academy of Science

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ORGANIZATION MEETING
SPRINGFIELD, DEC. 7, 1907

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FIRST REGULAR MEETING
DECATUR, FEB. 22, 1908

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# TRANSACTIONS

## ORGANIZATION MEETING

SENATE CHAMBER, SPRINGFIELD, DEC. 7, 1907.

## MINUTES.

MORNING SESSION.

The meeting was called to order by A. R. Crook, Curator State Museum, at 10 A. M.

Upon nomination by H. Foster Bain, U. S. Grant, Northwestern University, was elected temporary chairman.

After a few words of introduction, the chairman presented to the assembly, Secretary of State James A. Rose, who, in the absence of the Governor, welcomed the company to the State Capital, and spoke concerning the desirability of effecting an organization of scientific men along lines similar to those already followed by men of many professions and callings in the State.

T. C. Chamberlin, University of Chicago, gave the opening address, on "The Advantages of a State Academy of Science," and S. A. Forbes, State Entomologist, gave an address on the "History of the former State Natural History Societies of Illinois."

On motion of S. W. Williston, University of Chicago, A. R. Crook was elected temporary secretary, and it was voted that the Chair appoint a committee of three on organization. This committee was to add six others to its number, and these nine were directed to draw up a constitution and nominate officers.

The Chair appointed S. W. Williston, University of Chicago, W. A. Noyes, University of Illinois, C. B. Atwell, Northwestern University; and this committee added T. C. Chamberlin, University of Chicago, S. A. Forbes, University of Illinois, A. R. Crook, State Museum, F. L. Charles, Northern Illinois State Normal, H. V. Neal, Knox College, and B. B. James, Millikin University.

While the committee were at work, a general discussion concerning the plan and aims of the organization was participated in by various speakers.

C. E. M. Fischer, College of Physicians and Surgeons, called attention to the desirability of affiliating with various existing organizations.

T. W. Galloway, Millikin University, suggested that the committee on organization report early.

C. W. Andrews, John Crerar Library, suggested that the committee make possible the admission of libraries and other institutions to membership in the organization, and expressed the interest which such institutions as the one with which he was connected would feel in the movement.

T. J. Bryan, Illinois State Food Commission, spoke in behalf of the interests of the men who are not engaged in teaching but are interested in technical work.

Q. I. Simpson, of Palmer, spoke from the standpoint of one occupied with practical application of scientific principles in stock breeding and thought that the academy would be of great advantage to men of science engaged in application rather than investigation.

T. J. Burrill, University of Illinois, suggested that the singular rather than the plural of *science* be used in the naming of the academy, and that a definite home and one place of meeting would add to its effectiveness.

Edward Bartow, University of Illinois, said that the organization would not only promote general interest in science, but would increase each member's enthusiasm for his own work.

Albert Carver, Springfield High School, enumerated some advantages to be gained by holding meetings of the academy in Springfield.

Isabel S. Smith, Illinois College, hoped that the academy would lend its influence towards saving the forests and especially the remnants of the pine forests in the State.

R. H. McKee, Lake Forest University, mentioned the desirability of small fees being charged by the new organization, and that the place of meetings should alternate between different parts of the State.

F. D. Haddock, Superintendent Public Schools, Champaign, said that while a superintendent should give all lines of work equal consideration, he wished to express his great interest in science and the work of the academy.

C. G. Hopkins, University of Illinois, thought that the academy would be of service both to pure and applied science.

Henry Crew, Northwestern University, cautioned against too minute division of the academy into sections. He thought the departments might well be grouped so that there would be but two sections—such as that of natural and physical science or of pure and applied science.

E. J. Townsend, University of Illinois, thought that the sections should not be too small. The meetings should be held at different places, meeting in alternate years in the State Capitol.

W. S. Bayley, University of Illinois, thought that the dues should be as low as possible and the sections given a place of minor importance, since it was desirable for the academy to

extend its influence broadly rather than minutely. One of the great advantages would be the opportunity which it would furnish for specialists to gain interesting facts outside of their own lines. He suggested that the secretary should be in Springfield in order to keep in touch with legislation.

Miss Stella M. Hague, Rockford College, expressed her interest and that of Rockford College in the organization.

W. F. M. Goss, University of Illinois, advocated caution in dividing the academy into sections, and the importance of keeping in mind the larger interests.

H. A. Gleason, University of Illinois, called attention to the inspiration and help which the academy might afford younger men.

F. C. Gates, Chicago, thought that the high schools should be in touch with the academy.

W. E. Loomis, Springfield, spoke in the interest of astronomy.

A. W. French, Springfield, expressed the hope that the academy would do much towards advancing scientific spirit and knowledge.

The meeting then adjourned till 2 P. M.

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## Afternoon Session.

### 2:15 P. M.

Meeting called to order at 2:15 P. M. by the president pro tempore.

Upon motion of S. W. Williston, chairman of the committee on constitution, the draft of the proposed constitution was presented. It was read by the secretary of the committee, F. L.

Charles, and upon motion of H. F. Bain, it was considered section by section.

After revision and discussion the constitution and by-laws as given below were adopted.

It was voted that the first annual dues should apply for the year 1908.

S. W. Williston presented the report of the committee on nominations. It was voted that the secretary cast the ballot for the following officers, and they were declared elected:

President, T. C. Chamberlin, University of Chicago.

Vice-President, Henry Crew, Northwestern University.

Secretary, A. R. Crook, State Museum.

Treasurer, J. C. Hessler, James Millikin University.

Third member of Publication Committee,

H. F. Bain, State Geological Survey.

Committee on Membership:

S. A. Forbes, State Entomologist.

T. W. Galloway, James Millikin University.

J. P. Magnusson, Augustana College.

C. H. Smith, Hyde Park High School.

B. B. James, James Millikin University.

President pro tempore Grant then introduced the President-elect.

In the absence of the Treasurer, B. B. James, of James Millikin University, was appointed Treasurer pro tempore.

A symposium upon the "Outlook for Young Men in Various Sciences" was participated in by W J McGee, J. G. Coulter, Wm. A. Noyes, H. F. Bain, Henry Crew and H. V. Neal.

The membership committee was authorized to accept as charter members those persons who had previously expressed their desire to be enrolled as such, but were unable to be pres-

ent at the meeting. The committee acted upon the names submitted.

Upon motion of W. E. Loomis it was voted that 500 copies of the proceedings of the organization meeting be printed and that one copy be furnishel to each member of the Society.

The meeting then adjourned till 8 P. M.

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## Evening Session.

In the evening, to an audience of about six hundred, Dr. W J McGee gave his lecture on "Greater Steps in Human Progress."

His address combined in a rare degree such facts as would attract men of the highest scientific attainments and at the same time the more popular audience also. It might be expected that such a title, "Greater Steps in Human Progress," would imply consideration of the remarkable manufacturing and commercial advances which have characterized the last century. His plan, however, was to note various habits and discoveries of men which indicate evolution from a low physical and mental equipment to the full expansion of man's faculties. Primitive men were unable to open the hand so as to bring the thumb in the same plane with the fingers. This was shown by the aboriginal Philippine tribes which Dr. McGee assembled at the St. Louis Exposition.

Primitive man is characterized by movements of the hand and arm *toward* the body, whereas his more highly developed descendants directs these movements *from* the body. It is the Anglo-Saxon who has shown this development in the highest degree, and while in other respects prize-fighting is indicative of the lower traits, in this one fact, namely, that the motions of

the arm in a well-directed blow are from the body of the fighter, the prize-fighter's profession indicates high physical development—a real step in progress.

The savage grasps a knife with the blade held towards the body. Civilized man holds the blade from the body. The mistress wishing to judge the mental alertness of a prospective maid servant should hand her a plate and towel, noting the motion of the hand as the maid wipes the plate. If the motion of the right hand is clock-wise the maid should be considered a promising subject.

At some length Dr. McGee illustrated the fact that the development of "knife sense" is one of the greatest steps in human progress. Primitive men used a rounded stone and had no conception of the value of a sharp edge.

Another one of the great steps, and indeed the chief one, is in the use of fire. Man alone of all created things employs fire. It required long ages for men to learn the use of fire, and this discovery has made possible the great development of the human race, socially, commercially and intellectually.

Finally, the faculty of invention is one which has contributed most forcibly and characterized most materially the development of the human race.

The address was a masterly presentation of unique and original material.

The interest which was displayed throughout the meeting, argues well for a successful and useful career for the society.

A. R. Crook,
*Secretary.*

# CONSTITUTION AND BY-LAWS

## ILLINOIS STATE ACADEMY OF SCIENCE.

### CONSTITUTION.

#### ARTICLE I. NAME.

This Society shall be known as THE ILLINOIS ACADEMY OF SCIENCE.

#### ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

#### ARTICLE III. MEMBERS.

The membership of the Academy shall consist of *Active Members*, *Non-resident Members*, *Corresponding Members*, *Life Members*, and *Honorary Members*.

*Active Members* shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

*Non-resident Members* shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

*Corresponding Members* shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

*Life Members* shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

*Honorary Members* shall be persons who have rendered dis-

tinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908 become charter members.

### Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

### Article V. Council.

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

### Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

### Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

### Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

### Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

### Article X. Amendments.

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

## BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.
11. Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

# ADDRESSES

## THE ADVANTAGES OF A STATE ACADEMY OF SCIENCE.

T. C. CHAMBERLIN.

The opening address, by Professor Chamberlin, on *The Advantages of a State Academy of Science,* was given in the extemporaneous form, and the following outline very imperfectly represents what was said.

Professor Chamberlin introduced his address by conveying the felicitations of the Chicago Academy of Sciences, and sketched some of the salient features of its history of a little more than fifty years as a means of giving concrete illustration to some of the problems which the new academy must face. Special attention was directed to the radical change in the nature and relations of scientific activity since the oldest academies of the interior were established. In the pioneer days, an almost virgin field was open to naturalists, and enthusiasts in this field constituted the largest factor in the membership of its academies of science during their early stages of development. The results of these pioneer workers were much more fully within the appreciation of all their colleagues and of the intelligent public than are the products of the more highly specialized investigations of today. So widely has research deployed in the last fifty years, and so far has it reached into the

more recondite phases of each field, that there is now far less community of interest and of intelligent appreciation, even among scientific workers themselves. This fundamental change brings new problems of organization and of adjustment. In like manner, the function of an academy as an avenue of publication has assumed a new aspect. Fifty years ago, an appropriate means of publication was one of the greatest needs which the academies supplied to the pioneer workers, for, aside from these academies, the available opportunities of giving publicity and permanence to scientific results were few and unsatisfactory. As the regional element was dominant in the results of the early naturalists, it was fitting that there should be a local means of publication. Today, however, the results of research are, in general, more serviceable to scientific workers if they are gathered into the special journals devoted to the several departments of science. While the function of publishing the results of regional investigations still remains, and may well continue to be subserved by the regional academies of science, and while certain adaptations of other results may serve an important regional purpose, the question whether an academy should endeavor to be the avenue of miscellaneous publication to the same extent as in the early days is one of the problems that invite the serious consideration of a new academy.

Attention was also directed to the problems presented by the geographic distribution of the centers of scientific activity within the State and by the not altogether felicitious relations of these centers to the capital of Illinois.

The advantages of a state academy to those who are just entering upon scientific careers, to amateurs dissociated from institutions of research, to trained workers in relative isolation, and to workers in scientific centers, were specifically set forth. The values to be derived from opportunities of reading papers

before fellow workers, of submitting results to discussion, of participating in the discussion of others' results, of extending scientific acquaintance, of co-operation, of mutual stimulus to endeavor, of personal education by contact with other workers, were dwelt upon in detail. The value of the academy as a means of disseminating the spirit, the method, and the love of science among the people of the State was especially emphasized. The function of advising relative to legislation on scientific matters was urged as highly important.

The address closed with an earnest advocacy of the value of the spirit and method of science to the state and nation as an essential element in the solution of its great social, political, and ethical problems. The habit of conscientious search for the precise truth and the systematic control and guidance of opinion and action in accordance with the canons of scientific procedure were urged as means of supreme value in the elevation and purification of the common thought and feeling of our people. More than anything else, are the intellectual and moral methods of science a protection against current evils and a guarantee of safety in the future.

# HISTORY OF THE FORMER STATE NATURAL HISTORY SOCIETIES OF ILLINOIS.

S. A. FORBES.

The history of scientific organization is a part, merely, of the history of scientific progress, and that is a part of the history of the progress of civilization, and especially of education; and the subject which I am to present is no exception to this rule. It is difficult to omit from even a brief abstract of the history of the Illinois natural history societies all reference to the character and status of the general movements of which they were scarcely more than by-products, and still to leave in the account enough significance to make it worthy of presentation here. Under these circumstances I shall be governed by the reflection that we are today looking forward and not back —that we are preparing for the future and not studying the past—and that we are hence practically interested in what has come and gone only as it may help us to bring a new thing into being in a way to secure its permanent continuance and its normal growth. There have been two state natural history societies in Illinois, one founded in 1858, and the other in 1879. The first was the result of a proposal by an entomologist, Dr. Cyrus Thomas, afterwards State Entomologist of Illinois, made at a meeting of the State Teachers' Association at Bloomington in 1857. The second sprang up as a sequel to the sessions of a summer school of natural science held at the State Normal School, at Normal, and had for its first president, the state

geologist, A. H. Worthen, and for its first secretary, the present writer, then in charge of the museum of the old society in the State Normal building.

The first society was chartered by the state legislature in 1861; held its tenth and last annual meeting in 1868; published, in 1861, Volume I., series 1, of its *Transactions* (in Volume IV. of the *Transactions* of the State Agricultural Society, and again, in a second edition, in 1862, as a separate pamphlet, a rare copy of which I hold in my hand); formed a museum of natural history which was housed in the building of the State Normal School, at Normal; and held two final business meetings in Bloomington, May 26 and June 22, 1871, for the transfer of its museum to the State in accordance with a provision of law passed by the general assembly of that year. This museum, held by the State Board of Education "for the use and benefit of the State," was gradually transformed, in due time, into the present State Laboratory of Natural History. A part of its original material is now in the possession of that institution at Urbana, a part of it belongs to the State Normal School at Normal, and the remainder is in the State Museum of Natural History, founded here in 1879, and now in charge of Professor Crook as its curator.

The officers of the society mainly responsible for its establishment and growth were its corresponding secretary, later called its general commissioner, and the curator of its museum. The former was its field agent and general manager, and the latter was the custodian of its collections. Its first corresponding secretary was C. D. Wilbur, who served in that capacity until 1864. Its curator was for several years Dr. J. A. Sewall, instructor in chemistry in the State Normal School, at Normal, and afterwards president of the Colorado State University. Its second general commissioner, and afterwards the second

curator of its museum, was Major J. W. Powell, who was in its service in the latter capacity when he made those remarkable western explorations, and especially that most remarkable expedition down the Colorado River of the West, which gave him world-wide fame and did much to make him later the United States Geologist. The third actual curator, serving, however, nominally as Major Powell's deputy, was Dr. George W. Vasey, afterwards for many years botanist to the United States Department of Agriculture, at Washington; and the last to serve in this capacity was the present writer, appointed by the State Board of Education in 1872, after the State had acquired the museum, and continued as director of the State Laboratory of Natural History after the change of name and function finally made in 1879.

This society came into existence at a time so different from our own that we can derive little from its experience by way of either warning or instruction. Its period was that of the first active exploration and discovery of the scientific contents and economic resources of our territory, and of the first general impulse to the scientific education of the people; and the society was formed as an agency for a natural history survey of the State in the old sense of an accumulation of museum specimens and a descriptive record of its zoology, botany and paleontology—meteorology and physical geography being nominally included, also, within the scope of the society. In 1858 the State Geological Survey was just getting on its feet, with Mr. Worthen appointed that year as its director. The normal school at Normal was the only state educational institution in Illinois, and that has been organized only one year. The state university was not founded until nine years thereafter, at which time, also, the state entomologist's office was first established.

Very few of the men engaged in the work of this old so-

ciety had anything approximating what we would now call a scientific education, and few of them were what we would now call professional scientists or teachers of science, and yet they were evidently the pick of the State in scientific ability, enthusiasm and activity. Among its more efficient members, besides Powell, Vasey, Worthen and Thomas, already mentioned, were Benjamin D. Walsh, the first state entomologist; M. S. Bebb, well known for his work on the willows of the United States; Dr. Oliver Everett, of Dixon; James Shaw, of Mt. Carroll, and Dr. Henry M. Bannister, the last two assistants on the Geological Survey; Dr. J. W. Velie, a life-long ornithologist, still living in Michigan; and Dr. Frederick Brendel, of Peoria, author of many botanical papers, and also still with us, one of the very few survivors of the early membership. I must not omit, even in this briefest mention, the name of Professor J. B. Turner, of Jacksonville, first president of the society, famous in the history of the state universities because of his leadership in the pioneer movement for an industrial education of college grade; nor Dr. Edmund Andrews, of Chicago, who became one of the leading surgeons of that city; nor Newton Bateman, state superintendent of public instruction, who lent to the society the prestige of his great name—a most potent educational influence in that day.

You will wish, I am sure, to know something of the subjects in which the more prominent members were interested, and on which they wrote their papers for the society programs, and I will mention a few of them, taken at random. By Dr. Brendel: "Forests and Forest Trees of Illinois," "The Trees and Shrubs of Illinois," "The Oaks of Illinois," "Meteorology in connection with Botanical Investigations," "Additions to Robert Kennicott's Flora of Illinois." By Dr. Everett: "The Geology of a Section of the Rock River Valley." By A. M.

Gow, of Dixon: "Natural History in Schools." By R. H. Holder, of Bloomingon: "A Catalogue of the Birds of Illinois." By James Shaw: "The Great Tornado of 1860." By Dr. Thomas; "Insects of Illinois, with Catalogue of Coleoptera," "Mammals of Illinois." These latter papers, it scarcely need be said, were extremely slight sketches of their subjects. By Dr. Vasey: "Additions to the Flora of Illinois," "The Pernicious Weeds of Illinois," "The Range of Arborescent Vegetation." By Mr. Walsh: "Insects Injurious to Vegetation in Illinois," "The Army-worm and its Insect Foes," "Insect Life in its Relation to Agriculture." By Mr. Wilber: "The Mastodon giganteus, its Remains in Illinois." Most of these papers were published in the Transactions of the State Agricultural Society, some of them also in the *Prairie Farmer*, of Chicago, those being virtually the only avenues of publication open to students of science in Illinois in that day.

The society operated through an elaborate organization of special committees of its members, one for each division of the natural history of the State, each committee composed, of course, of unpaid volunteers, who were made responsible for the accumulation and preparation of material for their several departments of the museum, and for contributions on their respective divisions of its natural history. This survey work was extremely irregular in amount and unequal in value, and its results were never organized by the society into a working collection. The curator was an instructor in the normal school, and seems to have received no pay from the society; but the general commissioner was supposed to give his entire time to its service. His salary was evidently uncertain in amount, and dependent largely on his success in securing entrance fees from new members. Financial complications arose—disputes as to ownership of property, difficulties in the payment of debts in-

curred, refusals to turn over to the treasurer the funds claimed by the society—and these, with other confusing and discouraging conditions, led to the withdrawal by members of gifts and deposits of specimens and a falling off in the active membership. The society finally collapsed, chiefly because of its financial disabilities. Since it could neither pay adequately its general commissioner or its curator, nor organize its collections or publish its papers from its own resources, it turned to the State for aid, and found itself ultimately obliged to accept the condition that its property should be transferred to the State, and that its curator should be appointed by a state board, as the price of continued appropriations,—which, by the way, were largely drawn upon to outfit and maintain the Powell expeditions to the far west.

There is no doubt that this short-lived society brought a body of influential public opinion to the aid of state scientific and educational enterprises appearing during its existence, and that it did much to stimulate a general interest in scientific knowledge and research, and thus to hasten the introduction of the sciences into the public schools—influences which did not cease when its own organic life was ended. It also afforded to Powell the standing-ground from which he leaped into fame as an explorer and won his way to a scientific career of the first importance, and it left in its museum nuclear collections which were later made useful in a revival and firm establishment of the original enterprise of the society, modified to suit more modern ideals, by the State Laboratory of Natural History. This first state society thus gave indirect origin to the state laboratory, with which the state entomologist's office became practically identified in 1883, much as the first geological survey of the state gave origin to our present state museum. If our new academy do no more, proportionately to its period

and its environment, within the next ten years, it will amply justify our proceedings today.

By 1879, after an interval of eleven years from the actual dissolution of the old society, a virtually new situation had arisen in science, and especially in scientific education. Under the influence of Darwin and Agassiz and Huxley a transforming wave of progress was sweeping through college and school—a wave whose strong upward swing was a joy to those fortunate enough to ride on its crest, but which smothered miserably many an unfortunate whose feet were mired in marsh mud. This wave reached central Illinois in the early seventies with the effect to bring about, in 1875, a summer school of natural history at the State Normal School—only two years, it will be noticed, after the first session of the Agassiz school at Penikese. Wilder, of Cornell, and W. S. Barnard, just back from Europe with a doctor's degree, were members of its teaching staff, together with Burrill, of the State University, Thomas, the state entomologist, and the present writer, who was also director of the school. Besides an abundance of living plants and animals of our own environment, we had great boxes and barrels of marine material in large variety, some of it received alive, secured by a most active collector engaged for the purpose, who scoured the New England coast for us from Fortland to Buzzard's Bay. This school was a notable success, except that the Illinois instructors all worked for nothing and paid their own expenses, but the Centennial Exposition of 1876 deranged plans for its immediate continuance. In 1878, however, a second equally successful session was held, at the close of which its students spontaneously organized themselves into a natural history society, and appointed a committee of correspondence to extend its membership and enlarge its scope. As a consequence of the numerous and

unanimously favorable responses to the letters following, a conference was held at the office of the state geologist in Springfield, December 12, 1878, and the secretary of this conference was instructed to call a convention at Chicago for the organization of a state natural history society.

Some forty persons responded to the call, and organized at the Palmer House, January 16, 1879, and letters were read from fourteen others who wished to join the proposed society. The first officers were A. H. Worthen, of Springfield, President; T. J. Burrill, of Urbana, and H. M. Bannister, of Chicago, Vice-Presidents; Homer N. Hibbard, of Chicago, Treasurer; S. A. Forbes, Secretary; and Selim H. Peabody, of Champaign, and Cyrus Thomas, of Carbondale, additional members of the executive committee. By the close of the year sixty-six members had paid their initiation fee of three dollars each.

This was the period of the return to nature in the study of science, and annual field meetings were provided for. The first of these was held at Ottawa, July 10, 1879. Dividing into three sections—geological, botanical and zoological—under the leadership of Worthen, Burrill and Forbes, respectively, the society took to the woods in the beautiful, prolific and historically interesting valley extending along the Illinois River eighteen miles from Ottawa to Peru, and with Starved Rock, Deer Park, Buffalo Rock and the site of the famous Indian village at Utica within or near its boundaries.

Annual program meetings followed at Bloomington, Springfield, Urbana, Springfield, Peoria and Jacsonville; and field meetings at Lake George, Indiana, near Chicago, where a Chicago sportsmen's club placed their club house, premises and equipment at our disposal; at Fountain Bluff and Grand Tower, on the Mississippi, in southern Illinois;; at Warsaw, in Hancock county, the home of Mr. Worthen; and at Peoria, where

the Peoria Scientific Association joined us in a steamer trip up the Illinois River for aquatic work. These field meetings were well attended, as a rule, and were much enjoyed, although it must be confessed that they were perhaps more agreeable than permanently profitable to us. The annual meetings also were interesting to the participants, and did something, no doubt, to stimulate the workers among us, and something also to interest and instruct the communities in which they were held. Their average character may be well enough illustrated by the program of the Urbana meeting in 1882.

The first session was devoted to an address on "Primitive Religion in America," by Mr. McAdams, of Jerseyville, which was substantially an account of the religion of the Mound Builders as inferred from idols and other implements of a religious character which had been collected by the speaker. During the next session, Dr. Edwin Evans, of Streator, read a paper on "The Rock System of the Northwest," based mainly on the records of borings for artesian wells, and illustrated by maps and colored diagrams. This was followed by a paper on "Recent Microscopy," by Professor Burrill, of the university, giving a historical account of the development of the miscroscope and a description of its most recent improvements and performances; and this by a paper on "Prehistoric Remains in Southeastern Missouri," by F. S. Earle, of Cobden—essentially a classification and general description of mounds studied on a trip made for the Smithsonian Institution. A lecture on "The Fossil Tracks of the Connecticut Valley," by Don Carlos Taft, professor of geology in the university; a paper on "The Army-worm in 1881," by F. M. Webster, of Waterman; and one on "The Organs of the Sixth Sense of Blind Fishes," by S. A. Forbes, completed the program of the first day, which was followed by an evening reception to the society by the

faculty and students of the university, and a microscope display given jointly by the university and the society.

The program of the following day contained a paper on "Sciences in the Public Schools," by C. W. Rolfe, of the university; one by Mr. McAdams on "The Great Cahokia Mound of Madison County," of which the writer has just completed a survey; one by Professor Burrill on "Some Vegetable Poisons," and one by Mr. Forbes on "The First Food of the Whitefish." Professor N. C. Ricker, of the university, read a paper on "The 'Blue Process' of Copying by Photography," just coming into use for the duplication of papers and drawings; James E. .Armstrong, of Champaign, gave an account of the life history of a jellyfish studied by him at Beaufort, N. C.; Dr. Evans gave a paper on "The Subterranean Waters of the Northwest" —a discussion of the origin of the artesian waters of northern Illinois and southern Wisconsin; Mr. A. B. Seymour, botanist to the State Laboratory of Natural History, read a paper on "Field Work on Parasitic Fungi;" Mr. Cyrus W. Butler, also a state laboratory assistant, gave some zoological notes from the field-book of a naturalist; J. E. Armstrong presented an abstract of the papers read at a recent meeting of the University Natural History Society; and Professor Rolfe read brief papers on "Experiments with Germinating Seeds," and on "The Rings of Wood as indicating the Growth of Trees."

In 1880 the question of an enlargement of the field of the society to include the physical and mathematical sciences came up for discussion, and was decided negatively, on the ground that the interests represented by physicists, chemists and mathematicians were so separate from those of the naturalists that a common society was not desirable—a conclusion perhaps warranted in view of the kind of naturalists that most of us were.

In 1882, when the treasurer reported a balance of $150 in his hands and $122 more due from members in annual fees, the question of a publication of papers and proceedings was brought forward in the secretary's report and referred to a committee; but no steps were taken to that end on the ground that it was not desirable to multiply centers of publication unnecessarily, and that there was no lack of opportunity to publish really valuable papers in established periodicals.

Following upon these conclusions, and possibly in part because of them, the paid-up membership of the society began to decline. Indeed, of the sixty-six persons who completed their membership during the first year, thirty-nine did not continue their payments thereafter, and at the end of the second year the actual paid-up membership was fifty-two. The following year it was fifty-four, then fifty-two, then forty-three, and finally, in 1884, it fell to twenty-seven. The executive committe took these facts to indicate that there was at the time no sufficiently general and urgent desire for the permanent maintenance of a society of this description to warrant its continuance, and after the Jacksonville meeting of 1885, which passed without a formal election of officers, it was not called together again.

And now I hardly need say that, after the lapse of twenty-two years of amazing progress in science and in scientific education, an entirely new situation again exists in Illinois—one so radically different from that of the early eighties that the conclusions then reached have no very important bearing on our problem of today. There are more college specialists here today from one department of one institution than there were in our whole membership in 1879. Indeed that list is not so long that I cannot give it to you now, to emphasize the contrast. It consisted of J. D. Conley, of Carlinville; T. J. Bur-

rill, of Urbana; S. H. Peabody, of Champaign; Rev. Francis X. Shulak, of St. Ignatius College, and E. S. Bastin, of the old University of Chicago—five men, one of whom, Dr. Bastin, did not meet with us again. Lindahl, of Rock Island, and Marcy, of the Northwestern, joined us in 1880, and Robertson, of Carlinville, in 1882, and a few additional members of the faculty of the State University paid us the compliment of an initiation fee when we held our meeting at Urbana, but went no farther with us. If there was any professional or active worker in biology or geology at any other Illinois college at the time, we never made his acquaintance nor he ours. Of the state scientific officials there were only Worthen, Thomas and Forbes. Thomas left the state in 1883, but the other two stayed with the society to the end.

It should be remembered, in this connection, that this was a time when college men, as a rule, worked like dray-horses and were paid like oxen, and the sacrifice of time and means necessary to prepare adequately for the annual and seminnual meetings of the society, and then to attend them, was more than they could, or ought to, make, except for some really important end.

It will be seen that, under these conditions, our membership would now be largely classed as amateurs. The active members of the last two years were chiefly collectors of specimens, and species-students of the old school—a few still-glowing brands from the enthusiasms of the exploration period, with scarcely a spark to testify to the coming illumination, in the midst of which it is our present privilege to live. And so the society passed, leaving no permanent material product of its work, except private collections and such papers of its members as were published here and there, as each individual thought best.

Does this account seem discouraging to our present undertaking? I do not think that it ought to, but quite the contrary. If, under such conditions, with so little material, and—as a reasonable modesty perhaps requires that I should add—under such general management, it was possible then for us to organize a state natural history society and to keep it actively at work for seven years, we ought now, I think, with all our present comparatively immense advantages, to found a state academy of science which shall live and thrive at least for seventy years, and, for all that I can see, for seventy times seven—by which time we shall all have been long relieved from all our responsibilities, and the labors and the honors of scientific enterprise will have been handed on to our remote successors.

# SYMPOSIUM

## ON THE LOOKOUT FOR YOUNG MEN IN VARIOUS SCIENCES.

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### ANTHROPOLOGY.

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W J McGee.

In considering the promise of anthropology as a field for work by younger men, it should be remembered that the field is a particularly broad one. Other sciences find their object-matter and their opportunity in some special class of phenomena; anthropology deals with *man*, not only in general but also as a science-maker. Partly for this reason, the research is particularly attractive and especially stimulating and broadening; and other things equal the grasp of the specialist in this science ought to be—and generally is—large and strong.

Unfortunately the opportunities either for student or worker are less in anthropology than in some other branches of science. Thus far the subject is not well recognized in college curricula, while the pressure for development in other departments tends to retard its introduction. Just now, too, state, federal, and related institutions are concentrating activity along other lines, so that anthropology may be said to be temporarily in eclipse; and although this condition can not long persist, it is a present discouragement. The chief opportunities are those

presented by museums. Of course both naturalists and educators are aware that we are in the midst of an era of museum development, and that public museums especially are multiplying in number and extent far beyond all precedent—indeed the museum is the correlative both of object teaching in primary education and of scientific and technical training in advanced institutions, and thus meets a growing demand. Now it is noteworthy that the departments of anthropology in the museums of the country are particularly attractive both to casual visitors and to investigators, and that they are growing on the average more rapidly than other departments; which means that in museum corps the opportunities for anthropologic students average well. Of the branches of general anthropology, archeology is most attractive in museums, partly because of the wide-spread intuitive interest in human relics which draws visitors and contributors, and partly by reason of the abundance of material; next follows ethnology, with its preparations and other exhibits illustrating the types of mankind and the artifacts and customs by which peoples are defined and classified. There is a current tendency toward the differentiation of museums in two primary classes, viz., museums or art, including painting, sculpture, and other esthetic productions of mankind; and museums of nature and industry, comprising objects of natural history and all those objects and products of mankind not primarily esthetic in character. While both classes of museums afford opportunities for the would-be worker in anthropology, the latter is especially promising—for the industrial development of the world is of never ending and always increasing interest, and the human artifacts are susceptible of arrangement in series serving to satisfy the instinctive desire to understand sequential development, and hence meeting a large demand.

In one respect the field of anthropology is perhaps more enticing than that of any other science. In geology, for example, the great problems seem to have been worked out in such manner as to leave no function for a Hall or a Hilgard, a Lyell or a LeConte, a Playfair or a Powell; and it may be questioned whether biology affords proper scope for a Linne or a Darwin; for while the necessities and the opportunities are continually arising, they are connected rather with sub-problems than with the primary problems of the pioneers. Not so of anthropology. This science presents today primary problems in classification, in correlation, in tracing serial development and relation, in throwing light on the most fundamental questions of human life; and for the ambitious student, desirous of enlarging the field of human knowledge, these opportunities can not fail of attraction.

# OPPORTUNITIES IN BOTANY.

JOHN G. COULTER.

Some of us have been assured by those who have had to do with the program that the sharers in this symposium are not to feel themselves fettered by the specific limitations of their assigned topics. Hence my liberty in asking first, why we should be concerned at all in any special effort to increase interest in science work as a profession. General interest in science is another matter. as a profession. General interest in science is another matter. The aim of this symposium, however, appears to be to point out why a choice of their life work from the various branches of science is a desirable choice for young men to make.

It may be reasonably inferred, if only from the remarks made this morning in the discussion upon what shall be the dues of this organization (so happily placed at one dollar), that we have nothing very great in the way of financial compensation to offer. For that very reason, if we are good economists, should we not be the last to encourage more strenuous competition for the apparently limited number of real competences which exist for the sustenance of life workers in science? Yet we are most cheerfully engaged in doing that very thing. Though there may be far from enough to go around in generous portions, let us by all means have more in at the feast. There may be compensation in the extra-prandial proceedings.

An editorial in a recent science periodical estimates that few-

er than five thousand persons in the United States are professionally engaged in science investigation or in the teaching of science up to the research point. Of these it reckons that fewer than one thousand should be counted real contributors. What are one thousand among eighty millions? We must accept the fact that several European nations excel us in this respect.

It comes to mind that our inferiority herein may be due as much to absence in the minds of the educated public of the aims and actual work in science progress as to anything else. Herein is, perhaps, the best reason for such a symposium and for such an organization as has just been perfected. These words of Matthew Arnold seem appropriate:

"The great men of culture are those who have had a passion for diffusing, for making prevail, for carrying from one end of society to the other, the best knowledge, the best ideas of their time; who have labored to divest knowledge of all that was harsh, uncouth, difficult, abstract, professional, exclusive; to humanize it, to make it efficient outside the clique of the cultivated and learned."

The point is, then, that our real science workers are both too few and too remote from the general public. They work very largely in another world than the one of common conception. From the world of common knowledge they must, perhaps always, remain aloof. But may not the real value of their work be at least adequately conceived?

In Europe the magazines and even the shop windows furnish evidence of the popular interest in science progress. Wherever the forward movement is most active you catch a quick reflection of it in the popular press. There the public is said to be really much concerned of late with what is sometimes called the "passing of Darwinism." What does the American public know or seriously care about Darwinism being on its death-bed?"

Here our editors shun the rather dry and obscure authorities in favor of picturesquely worded and sensation-charged celebrities; and, reciprocally, the authorities shun the editors.

Yet are we not ready to admit that the modern aspect of "national progress" depends very largely upon the number of properly qualified persons who are engaged in science research, and, perhaps as much, upon the extent to which the general public follows their advance?

Does not the fault for this large American gap between science workers and the general public lie much with the scientists who have held aloof; who have rarely taken it as part of their task properly to popularize the problems on which they are at work; who have let misrepresentation go almost unchecked; who have done much to form a sort of aristocracy of their own kind?

But, wherever the fault lies, we must lessen the gap. The constitution we have just adopted explicitly commits us to this. Unless there develops more popular interest in the great truth search, in this and its many other aspects; unless there develops more feeling of personal responsibility in finding out for one's own self, and less of being easily satisfied with the first plausible explanation, then the national peril for lack of "clean truth" to which Dr. Chamberlin made reference this morning is surely not very difficult to perceive; a reference which, by the way, has some responsibility for this digression from my topic.

Specifically, of the opportunities in botany, we can say that the demand for trained botanists continues to exceed the supply. Such demand is, of course, especially for young men ready to begin their service at compensation less than the theoretical value of the service rendered. Further, it is almost exclusively a demand for men to whom the service means at least as much as the compensation. But, as such, it is unquestionably a vigorous and growing demand.

The most extensive employer of young botanists in America is the United States government, and we are very reliably informed that the various bureaus of the Department of Agriculture are in positive need of more men adequately trained in plant morphology and physiology than they can find. Such training is usually sufficiently well attained in two or, at most, three years of graduate study.

It is becoming increasingly difficult to differentiate between botanists pure and simple and special students of agriculture. Yet we are loath to lose good men through a mere juggling of terms, as botanist into agronomist or something like, even though the latter cashes in better. So, among present-day opportunities in botany should not be overlooked the one of being botanist in fact only, with sedulous advoidance of a name which suggests nothing of the large cash values upon which this section of the profession, under its many aliases, may justly pride itself.

For teachers of botany the market is still brisk, though the upward tendency is not perhaps so marked as in other lines of demand. Doctors of philosophy in botany are commanding beginning salaries in teaching positions which average about fifty per cent. more than those offered eight years ago. There are in the main, of course, positions of collegiate or equivalent rank. It is for teachers of lesser training that the demand has shown a barely perceptible falling off. But this is more than offset by the increasing demand for teachers of agriculture for the rural high schools. What botany in some quarters is threatened with losing as a high school subject, agriculture has already more than gained. Since the question has become very largely one of teaching much the same subject in a more efficient way, we may expect that botany, in this respect, will be a graceful loser.

In the Philippines a "practical" botanist is wanted in every

province, of which there are more than thirty, to take in charge the immensely important educational side of the problem, especially from the standpoint of the agricultural possibilities. No stereotyped problem here, nor meager compensation therewith!

The opportunities for amateur work in connection with the academy should, perhaps, receive a word of comment. Apart from its large educational function, I take it that the contributory work of the academy will confine itself, in the main, within state boundaries. With such limitation, and assuming the co-operation of a considerable and favorably distributed number of persons, an ecologically annotated geographic catalogue is perhaps the first task which suggests itself. Such work for such an organization has the peculiar virtue of simplicity in its individual parts, absolute necessity for extensve co-operation, and the very large value of the final symposium. The humblest sharer in the work may be thoroughly satisfied that his part is quite as important as almost any other part.

Of intensive area work in ecology, Cowles's work on the dunes and Gleason's quite recent study of sand-flat areas of the Illinois river forcefully suggest the considerable number of similar, yet untouched and equally attractive, problems within the state.

The native prairie plants, made historic by their striking floral aspects alone, remain undisturbed in but few and restricted areas. The salvation of a strip of native prairie large enough to reveal the original ecological factors may be already impracticable, but the academy may well have in mind the establishment of a state garden of the native plants.

Fresh acres in garden and field will be given each year to the new experiments in plant breeding, and here, too, the amateur may well lend a hand, though our agronomical friends may

question whether such a suggestion is pertinent among points for amateur *botanists*.

In closing, I beg to submit a definite suggestion for which I must again seek excuse in that incontestable statement of our president this morning, that in lack of clean truth there lies national peril.

Nowhere in our educational literature is the absence of clean truth more conspicuous than in the nature-study books which are in common use in the graded schools. Nowhere has the unauthorized word had wider play or more credulous following. Untrained teachers have had nature study thrust upon them and have turned with avidity toward whatever seemed to offer help. Composites of sentiment and inaccuracy have been liberally supplied as "supplementary reading."

The suggestion is that there be issued in the name and under the direct auspices of the academy a series of leaflets upon science topics suitable for use as material in nature study and geography. Such topics should be treated especially from the standpoint of the state in so far as they lend themselves suitably to such treatment. Such leaflets should be available to the public schools at low cost. An educational editor, perhaps a member of the standing committee upon publication, might have in charge the apportionment of topics to members willing to cooperate, and ample discretion in editing to suit the educational needs in view should be allowed such an editor.

In objection, the point may be raised that in its very infancy the academy would be rash to venture to finance such a scheme. It may be confidently stated, however, that funds sufficient for such purpose would be at the disposal of the academy in case such proposal meets its good will.

A similar service has been and continues to be rendered by the Cornell Nature Study and Agricultural Leaflets.

# OPENINGS FOR CHEMISTS

W. A. Noyes.

Eighteen years ago, as I was sitting in a cafe in Munich one evening, talking to a young Englishman, he said to me, "England has the present but America has the future." He meant, of course, that while England at that time stood in the forefront of progress, industrially as well as politically, the conditions were such in America, both in our command of natural resources and in the character of our people, as to make it practically certain that the lead in both respects must go to America in a not far-distant future.

In the years which have passed since that time, this prophecy has been going on toward a rapid fulfillment. As an illustration, we may take the manufacture of iron. At that time more iron was manufactured in England than in any country in the world, but within a few years afterwards the production in America exceeded that in England, and it is now very much greater here than there.

In this increased industrial activity in America, chemists have played and are playing a very important part. In this very industry of the manufacture of iron and steel, twenty-five years ago very few chemists were employed in this country, but today chemists are required not only in the large establishments where steel is produced, but in foundries and factories of all kinds where large amounts of iron are used.

What has happened in the iron industry has happened also in a great variety of other industries. To speak of the different lines in which chemists are today employed would be almost to give a list of the important industries of the country. There is in these and in chemical work in general a rapidly increasing diversity. During the past year the American Chemical Society has established an abstract *Journal* which intends to give an account of all new work in chemistry which is published in the world. The abstracts in this journal are classified in thirty divisions, and this illustrates the great variety of industries and directions in which chemists are interested.

The amount of knowledge which has been accumulated in chemical science is so great that I feel safe in saying that the detailed knowledge in this science is greater in amount than the whole mass of scientific knowledge in all sciences fifty years ago. I do not, of course, mean that the value of this chemical knowledge is greater than the value of the scientific knowledge fifty years ago, but merely that its amount is greater, and I say this for the purpose of emphasizing the diversity of interests among chemists.

It is estimated that there are about eight thousand chemists employed in the United States at the present time. One of the previous speakers has referred to an estimate that there are only five thousand scientific men in the United States. While I do not suppose that all of the eight thousand chemists can be properly classed as scientific men in the sense in which the term was used by the former speaker, I am inclined to think that this number indicates that there are many more scientific men in the United States than would correspond to that estimate. The increase in the number of chemists during the past twenty-five years has been very largely occasioned by the employment of chemists in the industries. A quarter

of a century ago, nearly all of the chemists in the United States were engaged in teaching, while today the majority are undoubtedly working in industrial lines.

But it is not merely in the industries that the number of chemists has greatly increased during this period. Thirty years ago very few educational institutions could have been found which had more than three or four chemists on their staff. In the institution with which I am connected, the staff includes more than thirty chemists who are engaged in teaching or research, and I do not think that the institution is unusual in this regard.

Very large numbers of chemists have also been required in recent years by agricultural experiment stations and by government bureaus. Since the enactment of the pure-food law especially, the demand for chemists to fill positions in connection with the bureau of chemistry has largely exceeded the supply of suitable men, and during the past summer many of those who have been called upon to answer inquiries for chemists to fill positions have been compelled to reply that they had no suitable candidate to recommend.

# OUTLOOK FOR YOUNG MEN IN GEOLOGY

H. Foster Bain.

Probably our academy can do no one thing more useful than to encourage the young men and women of talent who are looking forward to a career in science. By this is not meant a deliberate effort to divert men and women from other work to ours, but rather the holding out of a helping hand to those whose inclinations are toward a scientific career, but who hesitate for fear that there is either no work or no place for them.

It is well known that men of science receive relatively poor financial returns for their work. Capable and industrious workers make a good living, but rarely are able to accumulate wealth. This is true of geologists as of others, and I for one am by no means sure that a change in this regard would bring to our profession any larger number of men of the highest talent and devotion. Be that as it may, the best which can be now offered to the hesitating young man is a good living while he does his work. The opportunities for making his way are found in three lines of activity: (*a*) teaching, (*b*) survey work and (*c*) industrial positions.

Geology is seldom taught in high schools and secondary schools, though there is a strong and increasing demand for teachers in physiography. This affords an excellent opening for beginners. In the colleges, universities and mining schools, geology is taught as frequently as the other sciences, and there are, accordingly, as many positions open.

The largest number of professional geologists in this country are connected for a whole or a part of their time with official surveys or bureaus. The greatest of these is the U. S. Geological Survey, which in the season just closed maintained ninety-three geological field parties. These each included from one to three geologists or aids. In addition many of the topographic and other field parties were engaged upon work so closely related to geology as to afford suitable opportunity for service on the part of beginners at least. In the forest service and in other branches of government work still other men are employed. Thirty-one of the states now have state geologists or equivalent officers, and sustain more or less geological work. This work varies greatly in character from refined paleontologic investigations to the registering of mining prospectuses and bureau-of-information work. In some cases only a few hundred dollars are appropriated for the summer field-work, perhaps, of the professor of geology at the university, and in others several thousand dollars are given annually and ten or a dozen field parties maintained. State survey work, where available, offers peculiar advantages to the beginner, since on account of the small force there is less specialization.

In mining and industrial work geologists are finding an increasing number of opportunities. Many railways, mining companies, development companies, etc., now employ one or more geologists. This indicates a welcome change of attitude in the public recognition of our work, but for the time being it cripples survey work by drawing away many of the best men. These positions are eagerly sought and pay relatively well, but usually offer only restricted opportunities for research work and often prohibitive conditions as regards publication. It is to be hoped that in time these restrictions will largely disappear.

Granted, then, that properly equipped and willing workers may

rest assured of positions being open to them, the vital question remains as to the work to be done. To some extent, in geology, pioneer conditions have passed. In our portion of the world geologic mapping on some scale has very generally been done. In much of Canada, in Alaska, in parts of Mexico and in most of South America pioneer conditions, as regards geology, still prevail. Very little of either Africa or Asia has been carefully studied so that as regards systematic work alone the bulk of our task is still before us. If also we measure the work from the point of view of development of ideas, the task is even more attractive. Geology has heretofore been mainly in the qualitative state. Its workers have been busy developing the processes involved and have had only the crudest means of elimination when it was necessary to test one hypothesis against another. As Van Hise has pointed out, we have now at least entered into the quantitative stage, and this means nothing less than the reduction to an orderly basis of the accumulated observations of all the years past. As we accomplish this we shall change our science from an inexact one of hypothesis to an exact one of law; and we shall then stand on an equal basis as regards certainty with our associates of the physical and mathematical sciences. This is certainly a field large enough and important enough to attract the best energies of any man or woman. If our academy shall help to put the right man in touch with his problem and the means of solving it, we shall quickly justify its existence.

# OUTLOOK FOR YOUNG MEN IN PHYSICS

HENRY CREW.

*Mr. Chairman and Gentlemen*: Sudden and unexpected as this call is, I feel bound by the courteous manner in which the invitation is extended, to respond.

The opportunities offered by the science of physics may for convenience, at least, be grouped under the four following heads:

(1) *Research.*—To him who finds his "manifest destiny" in investigation, the recent discoveries of physical science have vastly multiplied the opportunities for new discoveries. To illustrate: when Hertz in the autumn of 1888 showed us how to produce electric waves, a tremendous field was opened to research. The various properties of waves of different lengths, under different conditions all had to be studied. Every year some new domain of this kind is made ready for occupation by the earnest and serious student.

(2) *Applied Physics.*—For him who has that practical turn of mind which characterized Franklin and has yet preserved an interest in pure science (which also characterized Franklin) there is always a rare opportunity. In the autumn of 1831 Faraday not only discovered the induction of electric currents, but also actually made an electric motor and an electric generator about the same time. But it was not until the late sixties that the dynamo became a commercial success. This delay is typical of the mental hysteresis which generally separates discoveries in physical science from their industrial applications.

It was seven years after Hertz's discovery of electric waves that Marconi showed them to have commercial value; and it has taken practically twenty years to employ them for trans-atlantic messages. In these intervening periods lie great opportunities for the alert "practical mind."

(3) *Engineering.*—Nearly all the great engineering concerns of America are looking for more men than they can now find of the broadly trained type—men who are acquainted, *at first hand,* with the general principles of physical science. A man may know every machine in the shop of an engineering firm and yet not know how to design a new mechanism to meet a new want or a new circumstance. What is demanded today is, therefore, not so much an acquaintance with present-day practise as a thorough mastery of the fundamental principles of engineering—and these are mainly the principles of physics.

4) *Teaching.*—The high salaries which engineering concerns are offering to men well trained in physical science and to men of executive ability have had the effect to leave vacant many excellent teaching positions in physics. The door is wide open for him who enjoys this line of work and who is willing to leave behind all hope of opulence.

# OUTLOOK FOR YOUNG MEN IN ZOOLOGY

H. V. NEAL.

In the ten minutes allotted, I shall attempt to answer six questions of special interest to those who are planning to enter zoology as a profession. Through the kindness of Professors Mark, Minot, Comstock, Sedgwick, Reighard, Lillie, Conklin, Ward and Jennings, who have generously responded to my appeal for information, I am in a position to state the outlook for young men somewhat from the standpoint of their experience. As far as possible, the answers to the questions relating to the topic assigned me will be given in the words of the above-named zoologists.

1. *How do the chances for getting good positions compare with those of a decade ago?*

All of the zoologists who have expressed an opinion on this question agree that the chances are much better than they were a decade ago. Professor Comstock writes: "I should say that they are much better. It is only fair to emphasize, however, that the man who takes up work along these lines purely as a financial venture, apart from other considerations, will be disappointed. And I should say also that a large part of the demand for entomologists in recent years has been due largely to the great increase of this kind of work in the Department of Agriculture at Washington. Many men have found places with Dr. Howard or have taken places vacated by others who have

gone to Dr. Howard. If the government support of this kind of work were to cease it would make a great difference in the chances for getting good positions."

Dr. Mark writes: "Have been surprised that the demand has increased so rapidly. This has been more noticeable in the field of comparative anatomy than in other lines during the past five or ten years."

According to Dr. Minot, "There is great difficulty in getting any men for positions in anatomical and zoological laboratories, and I believe that for a few years the opportunities will be unusually good. But for heaven's sake, do not encourage any mediocrities to go into science. If you can, have them Oslerized at sixteen."

Dr. Conklin thinks that the chances of a young man's going at once from his graduation to the headship of a department are probably not so great now "as they were a decade ago."

Dr. Jennings says that "it is difficult to get the men needed for positions in zoology, and this is true all along the line from assistantships up to full professorships."

2. *Is is ever necessary for a man with a doctor's degree to rest on his oars for a year because no desirable college or university position is open to him?*

The reply of Dr. Lillie is typical of the answers given to this question: "In the course of a good many years several of our doctors of philosophy have accepted positions in high schools and normal schools; in such cases it has usually been a matter of preference with them. So far as I know, there has never been a case of one of our doctors of philosophy being obliged to go without a position for even a year."

According to Dr. Jennings, "many excellent positions have gone to men without the doctorate."

3. *Does the number of desirable positions equal the number of candidates?*

Dean Ward writes that "there have been more desirable positions in zoology which have come to my attention in the last five years than I could have filled times over if every one of my advanced students had been ready to consider such opportunities. We have not been able to furnish enough teachers to supply the college demand, nor enough collectors and workers for museum and government positions. The expansion in connection with college teaching, the demand for more men in old institutions and for new men in those recently founded has exceeded the supply."

Dr. Reighard writes that in his department "the number of applications for candidates to fill positions in biology and zoology has for some years fallen far short of the supply. I have had about ten applications for the present year and have been able to fill *none* of them with men directly from my laboratory. Two were, however, filled with men who have recently been here. These were applications for *men* and for positions above secondary-school grade."

4. *Has the number of men entering zoology as a profession increased or decreased?*

"There certainly has been no increase in proportion to demand," says Dr. Jennings. Dr. Reighard, however, writes that "the number of students in advanced classes with the definite purpose of preparing to teach in institutions above secondary-school rank, is *less.*'

5. *Are any new fields opening up for zoological students?*

According to Dr. Sedgwick "The demand for men in physiololgy and sanitary biology is particularly brisk, especially in the latter subject. For several years it has been impossible to meet

the demands for young men properly equipped to fill positions in sanitary or industrial biology."

Dr. Reighard writes that "to a certain extent new fields are opening up: (*a*) I have had two applications within a month for men to fill positions in experimental research work, particularly breeding experiments, in agricultural colleges, under the Adams act. (*b*) There is a slowly increasing demand for men to undertake museum work. We have difficulty in keeping good museum men here. (*c*) Some of the older educational institutions are reorganizing their zoological departments and expanding them. (*d*) The normal schools are seeking men (and women) with the newer, ecological training, capable of organizing work along 'nature study' lines. I have had a couple of calls of this sort within a few months."

According to Dr. Jennings, "Some new fields are opening for zoological students. The various research institutions recently established take a number. The Adams act recently enacted by Congress promises to call a number into the service of state experiment stations, and has begun to do so already. I should judge that many more educational institutions require competent men in this line, or a greater number of them, than was the case a few years ago. On the whole, I should say that the prospects are excellent in zoology at present, particularly for the investigator."

6. *Is the demand for zoologists likely to continue as great as at present?*

There seems to be good reason to believe that the conditions which have kept up the demand for the past decade will continue in the next. Even financial depression such as that of the present time does not seem to diminish the number of students in higher institutions of learning. The policy of the General Education Board and of the Carnegie foundation will tend not

only to open up new positions for younger men, but also to make college and university positions more attractive.

From such considerations, we need not hesitate to encourage the exceptional man whose tastes lead him in that direction to enter zoology as a profession, with the well-grounded hope of attaining such a position as his talents deserve.

# TRANSACTIONS

## FIRST REGULAR MEETING.

JAMES MILLIKIN UNIVERSITY, DECATUR, FEB. 22, 1908.

## MINUTES.

### MORNING SESSION.

The meting was called to order by President Chamberlin, at 10 A. M., 96 persons being present. The minutes of the organization meting of December 7, 1907, were read and approved.

The Treasurer made annouuncements concerning payment of dues, and plans for the present meeting.

Prof. Forbes reported for committee on membership, list of names recomended for election and an additional list of names of persons whose nomination for membership had not been seconded. The persons properly nominated and recommended, were voted in.

The following papers were read:

Biotic Zones and Districts of Illinois.—Charles A. Harts.

A Case of Phosphorescence as a Mating Adaptation.—T. W. Galloway.

Some Problems connected with the Coals of Illinois.—S. W. Parr.

The Desirability of a Systematic Ecological Survey from the Standpoint of Plant and Animal Associations.—H. C. Cowles.

A State Ecological Survey.—E. N. Transeau.

A Virgin Prairie in Illinois.—H. A. Gleason.

Occurrence of Oil and Gas in Eastern Illinois.—H. Foster Bain.

Illinois Trees.—T. J. Burrill.

Plant Pathology in its Relation to other Sciences.—Ernest J. Reynolds.

President Chamberlin spoke on the desirability and a method of affiliating with other scientific societies in the State; gave an account of the discussion at the meeting of the Council which was called by the President, December 30, in Chicago; and invited those interested in considering plans to meet at 1:45, before the opening of the afternoon session.

Prof. Forbes stated that as the result of many years' labor a great mass of ecological material had been collected by the State Natural History Survey, named and labeled, and was at the disposal of students. He spoke of his gratification at the increasing enthusiasm for the work.

A. R. Crook expressed the hope that the Academy would aid the State Museum of Natural History in securing materials to illustrate both the mineral resources of every section of the State and the relation of animals and plants in various portions of the State to each other and to their environment.

C. C. Adams suggestd that definite work be taken up in order that a report could be made on some locality.

The meeting was then adjourned till 2 P. M.

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## Afternoon Session.

At 2:25 P. M. the Academy was called to order by President Chamberlin.

The following papers were presented:

Relation of the State Academy to the Natural History Survey of the Chicago Academy of Sciences.—Frank C. Baker.

Farm Water Supplies.—Edward Bartow.

President Chamberlin made an announcement concerning the publication of the transactions, requesting all who were taking part in the program to send copies or abstracts of their papers to the secretary, inasmuch as it is desirable to have a record of these papers to show the subject matter considered and the condition of science in the State at the present time. He expressed the hope that means for publication would be provided by the state legislature, as was customary in other states.

The chairman of the committee on membership presented an additional list of names and they were voted in.

It was voted upon motion of H. F. Bain that the chairman appoint a committee of five on the collection of drill records.

On motion of S. A. Forbes, the following resolution was adopted:

*Resolved,* That scientific organizations which enter into relations of affiliations with the Academy may each nominate one of its members to be a member of the Academy Council, who shall have the right to vote on questions specifically relating to matters covered by the terms of their affiliation, but not on other business.

On motion of H. F. Bain, it was voted to invite appropriate organizations to select some member of their company to represent them on the Academy Council while an ecological survey of the State is being made.

A symposium on "The Atmosphere," was participated in by T. C. Chamberlin, Albert P. Carman, H. C. Cowles, John M. Coulter, Wm. A. Noyes, Chas. E. M. Fischer, H. Foster Bain.

The meeting was then adjourned.

As the guests of W. F. Barnes, M. D., the members of the Academy were conveyed to the Decatur Country Club and entertained at a dinner which served to celebrate George Washington's birthday and the first meeting of the State Academy of Science in a most pleasing manner.

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EVENING SESSION.

At 8 P. M., A. A. Michelson lectured on "Recent Advances in Spectroscopy."

A. R. CROOK,
*Secretary.*

# ABSTRACTS OF PAPERS.

## BIOTIC ZONES AND DISTRICTS IN ILLINOIS.

CHARLES A. HART.

Temperature as a universal factor causes differences in the biota according to latitude, modified to some extent by elevation above sea-level, thus permitting the delimiting of life zones. In the United States the three principal zones in current acceptation are all represented in Illinois. Zones are limited according to distribution of characteristic species, and many species of each zone range into the borders of those adjacent to it. The ranging of Lower Austral and Transition species a considerable distance into Illinois should not be used as an argument for extending the boundaries of these zones over Illinois to such a distance as to unduly narrow the intervening Upper Austral zone, as some investigators have done in adjacent states.

Within the Upper Austral zone in Illinois, variations of soil, vegetal covering, and climatic conditions are definitely enough marked to permit the division of this area into a number of biotic districts; and these, together with the adjoining zones, give the following series from north to south:

1. Transition zone. Small area at northeast, including a large part of the Chicago area.

2. Northeastern sand area. About south end of Lake Michigan and headwaters of Kankakee River in Illinois.

3. Western and northwestern sand areas. In Illinois and Mississippi river valleys, exterior to Wisconsin morainic border.

4. Northern Prairie. Greater part of northern and central Illinois, as far south as latitude of Wisconsin morainic border in eastern Illinois.

5. Southern Prairie. From the Northern Prairie to the Ozark ridge. The life approaches that of the sand regions.

6. The Ozark Ridge and River Valley area. Life of southern type, and of rough, rocky forested ground, extending up the larger river valleys.

7. Lower Austral zone. Area south of main Ozark ridge.

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## "A CASE OF PHOSPHORESCENCE AS A MATING ADAPTATION."

T. W. Galloway.

There appears periodically in certain waters of the Bermudas, an annelid in which the phosphorescence is clearly a direct mating adaptation.

The worms are never seen except at mating time. They appear at dusk, quite regularly for three to five days, at intervals of approximately a month.

The female swims at the surface and is intermittently phosphorescent as the eggs are extruded. The males, which are deeper in the water, are at once attracted, and copulation takes place with wonderful uniformity and certainty. The males are somewhat phosphorescent, but, so far as can be observed, this serves no end in the mating.

If males are not attracted at the first display it is repeated, at short intervals, for three or four times.

In nature, the worm is not phosphorescent after the mating, apparently. In confinement, a dull phosphorescence may be produced by disturbance for an hour or more.

This phenomenon makes it possible to study the embryology of the species with exactness.

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## SOME PROBLEMS CONNECTED WITH THE COALS OF ILLINOIS.

S. W. PARR.

### I. WEATHERING OF COAL.

Summary of results:

(*a*) Submerged coal does not lose appreciably in heat value.

(*b*) Outdoor exposure results in a loss of heating value varying from 2 to 10 per cent.

(*c*) Dry storage has not advantage over storage in the open except with high sulphur coals, where the disintegrating effect of sulphur in the process of oxidation facilitates the escape of hydrocarbons or the oxidation of the same.

(*d*) In most cases the losses in storage appear to be practically complete at the end of five months. From the seventh to the ninth month, the loss is inappreciable.

(*e*) The results obtained in small samples are to be considered as an index of the changes affecting large masses in kind rather than in degree, but since the losses here shown are not beyond what seems to conform in a general way to the experience of

users of coal from large storage heaps, it may not be without value as an indication of weathering effects in actual practice.

Further studies are to be continued, having reference to actual storage conditions.

## II. Deterioration of Coal.

Summary of results:

(*a*) An exudation of combustible gases from coal occurs from the time of breaking out of the sample from the vein.

(*b*) An absorption of oxygen accompanies the exudation of hydrocarbons.

(*c*) Samples of coal in most carefully sealed containers are subject to deterioration.

(*d*) The process of deterioration is probably due to oxidation of hydrogen or hydrocarbons by means of the absorbed oxygen. It may also be due to a simple loss of combustible gases and the replacement of the same by non-combustible gases such as oxygen.

(*e*) The rapidity or extent of this deterioration varies with different coals but is probably most active during the first two or three weeks from the taking of the sample, and does not seem to reach a normal state till after a few months have elapsed. Further data on this point especially are necessary.

It is interesting, also, to bring together the averages of the results in the three tables for further comparison. There is thus afforded further evidence suggesting the fact of deterioration.

## THE DESIRABILITY OF AN ECOLOGICAL SURVEY OF ILLINOIS BASED ON PLANT ASSOCIATION.

H. C. Cowles.

The oft-repeated words "vanishing data" have no more apt use than in connection with our native plant associations. The state should be systematically surveyed by botanists and zoologists, and maps should be made, showing the distribution of the associations. Where topographic maps have been published, and especially where geologic folios exist, this work should be much more easily accomplished than elsewhere. A start has been made at this work in Chicago, but much co-operation is necessary for success. The Academy might well take up such work as this officially.

## A STATE ECOLOGICAL SURVEY.

Edgar N. Transeau.

The fact that the native fauna and flora of Illinois are rapidly disappearing, makes imperative a survey of the state which shall serve not only as a record of the past and present conditions, but which shall throw light upon certain fundamental biological problems.

Illinois by virtue of its geographic position offers exceptional opportunities for the investigation of the factors involved in the development of the prairie and the forest; the study of the post-

glacial migration of both plants and animals; the determination of the methods of competition between biotic associations belonging to four great centers of distribution; the relation of great tension lines to the origin of species.

The fundamental plan of such a survey should be geographic and involve the entire state. Its methods should be ecological and involve the study of both plants and animals from the point of view of the habitat. Taxonomic work should be subordinated to the investigation of biological problems. The bearing of such work upon agriculure, horticulture and forestry is well known. It is the one method of working up the biological resources of a state which will give results valuable alike to theoretical and applied science.

Such a survey carried out under competent direction will provide a fund of information for natural history students throughout the state; will be of assistance to every teacher of botany, zoology and geography; will aid in the solution of many biological problems; will advance our knowledge of the natural resources of Illinois; will aid in their conservation; and will suggest the proper methods for their development.

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## A VIRGIN PRAIRIE IN ILLINOIS.

H. A. Gleason.

Twenty miles northeast of Champaign is a five-acre strip of untouched prairie lying along a small stream. It contains a large number of the rare species of prairie plants, notably *Cypripedium candidum* and *Lilium umbellatum*. It is highly important that the strip should be preserved, and negotiations to that effect are already under way.

# OCCURRENCE OF OIL AND GAS IN EASTERN ILLINOIS.

H. Foster Bain.

The year just closed was a very prosperous one in the petroleum fields of Illinois. The area was extended rapidly to the southeast, many gaps were filled in, new and lower sands were tapped, additional pipe-lines were laid, a new refinery was built and the output was phenomenal.

At the close of 1906 the number of producing wells was estimated at 4,185, and 532 dry holes were known to have been drilled. The total number of producing wells January 1, 1908, may be estimated at 9,772, with 1,260 dry holes. At this rate 88 per cent. of the holes put down have proved productive despite the fact that the outlines of the field are at many points yet to be determined.

The first oil was shipped from this field in June, 1905, and the shipment for that year, all of which went out in tank cars, amount to 156,502 barrels. In 1906 a pipe-line was extended into the territory, and the shipments as reported by the Ohio Oil Co., were 4,385,470 barrels.

There are now collecting mains extending from north to south throughout the field and four 8-in. lines (or an equivalent) from Martinsville, the central pumping plant, eastward across Indiana. A new line has recently been put in service running westward to a large refinery built this year near Alton, Illinois, by the Standard Oil Co.

The pipe-line runs for 1907, given through the courtesy of the Ohio Oil Company, were as follows:

PIPE-LINE RUNS FROM ILLINOIS, 1907.

| | |
|---|---|
| January | 752,670 barrels |
| February | 918,620 barrels |
| March | 1,494,598 barrels |
| April | 1,823,024 barrels |
| May | 2,094,194 barrels |
| June | 1,830,633 barrels |
| July | 2,376,281 barrels |
| August | 2,398,895 barrels |
| September | 2,560,592 barrels |
| October | 2,818,952 barrels |
| November | 2,464,980 barrels |
| December | 2,201,265 barrels |
| Total | 23,734,704 barrels |

To these figures must be added something for the fuel oil shipped by cars from Duncanville, the oil used by the local refinery at Robinson, and the tank-car shipments of the Sun, Cornplanter and other independent companies, amounting to something over 800,000 barrels. The recorded production for the year is 24,540,024 barrels, and probably the actual production ran a little over this. The oil, in the main, grades 32 degrees or better, and sold at the standard price of 68 cents per barrel. Only a limited amount was lower and sold at 60 cents. Of the year's production, 12,610,618 barrels are stored in the field by the Ohio Oil Company and a large amount is in producers' tanks.

## OCCURRENCE.

The oil occurs in a number of isolated pools which, however, are being brought closer together by drilling. It is not improbable that they will eventually be found to overlap. To

the north they are higher stratigraphically, and also shallower in depth. The Westfield pool is in the upper coal-measures. Most of the oil in Crawford county seems to come from the lower coal-measures, well down toward the base. In Lawrence county there are three sands, the main production being from the Buchanan sand at 1,300 ft. This probably represents the Mansfield sandstone of the Indiana geologists, an approximate equivalent of the Pottsville strata of the East. The Kirkwood sand at 1,600 feet is in the Chester. Farther south in the Princeton, Indiana, the Chester group is also productive.

In general the year's work resulted in extending the field to the south and in connecting up intervening territory. Wildcatting was active in other parts of the state, but so far without much result. Some gas has been found near Medora, and one or two oil wells have been brought in at Sparta, but as yet too little has been done to test thoroughly any considerable portion of the field.

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## ILLINOIS TREES.

T. J. Burrill.

Illinois was originally a prairie country, but there were also large bodies of woodland. The northern and southern quarters were better wooded than was the central half of the area, tho the latter had many groves and belts of timber. The trees were of numerous species and often were finely developed specimens. The largest were on the rich lands bordering the streams, notably upon the "bottoms" of the Mississippi, Ohio and Wabash rivers.

A very large proportion of the forests have been cut off, until today there is supposed to be but 18 per cent. of the whole area which can be classed as woodland. On the other hand, multitudes of trees have been planted and in many instances have grown into great size. There is far less "timber" existing now than formerly, tho there may be as many living trees as there were before the white man began his sway.

Only eight species of coniferous trees are native to our area, none of which existed in comparatively large numbers, and some of which were closely restricted in distribution. The broad-leaved kinds are represented by eighty-two native species which may be called timber trees. Besides these, at least seven kinds which reach the size of large trees have been introduced and are now self-perpetuating. Numerous other kinds have been planted and have proved to be well adapted to the prevailing conditions.

The time has fully arrived for effective action by individuals, by societies, and by the State looking toward the preservation and better utilization of our natural forests and for the extension and improvement of woodlands. The local conditions and general needs should be exhaustively studied in order that the best provision for the future may be made. Illinois has comparatively small forest areas, but has needs for forest supplies and influences enormously large. These can in part be self furnished. It is surely time that the work should begin.

# PLANT PATHOLOGY IN ITS RELATIONS TO OTHER SCIENCES.

E. S. Reynolds.

In pursuance of the thought that science is a unit and not merely an aggregation of separate sciences, the relations of various sciences to plant pathology are to be considered. This science is defined as the study of the diseased conditions of plants, and its importance, as indicated by the large losses to the farmer caused by plant diseases, can not be overestimated.

The relations existing between pathology and botany are very close: In morphology we must study the natural and diseased forms and structure of plants, as well as the morphology of the attacking parasites; in physiology the normal and abnormal functions of host and of parasites must be investigated; from bacteriology many methods have been adapted to pathological study, and, as many diseases are caused by bacteria, the paths of the pathologist and of the bacteriologist cross; many diseases attack our woody plants and greatly endanger our forestries, thus bringing forestry and pathology into intimate relations.

When we turn to the other sciences, zoology attracts our attention, for insects and other animals either cause or carry many diseases. The diseased conditions in plants may cause disease in those animals which feed upon them. Between chemistry and pathology some intimate relations exist. The manufacture and use of fungicides, and the contributions of chemistry to our knowledge of the normal and abnormal plant products make evident these relations. The problems in plant pathology which relate to physics as well are even more subtle, for in these we must study such questions as involve the process of osmosis in plants, the ascent of water in trees, etc., and the influence of parasitic growth upon these processes.

# THE RELATION OF THE STATE ACADEMY OF SCIENCE TO THE NATURAL HISTORY SURVEY OF THE CHICAGO ACADEMY OF SCIENCES.

F. C. Baker.

The relation of the State Academy of Science to various existing institutions is a matter for serious consideration, because the question is at once raised, "Can the State Academy perform any work which can not be equally as well done by some society already established?"

In addition to the social advantages offered by the State Academy it would seem that its most important work will be its relation to the various institutions as a central governing body, so far as the scientific work connected directly with the State of Illinois is concerned.

Provision should be made for a complete biological survey of the state, of such an exhaustive character as to leave no part of the area unknown. Much of the past work has been scattered over widely separated areas and has not been properly co-ordinated. The state should be divided into distinct areas, which should be thoroughly explored and the results co-ordinated with other similar areas. The method used by the Natural History Survey of the Chicago Academy of Sciences could be adopted with equal benefit in a general survey of the state. This survey covers Cook and Du Page counties and a part of Will county, embracing an area of about 2,500 square miles. Each lake, pond, creek and river has been thoroughly surveyed by a number of collectors and students, and the results have been turned over to the Academy and have resulted in the publi-

cation of six bulletins, and it may be safely said that there is no equal part of the state as well known, so far as the work has been published.

It is believed that the entire state should be surveyed in a similar manner. Should the State Academy seriously consider a biological survey, the relation of the Natural History Survey of the Chicago Academy of Sciences to this survey would be that of general supervision of the work in northeastern Illinois. It would seem that the various institutions scattered over the state should have general charge of the work in their immediate vicinity, which would later be co-ordinated by the State Academy. The State Academy might also, with great benefit to the scientific workers of the state, act as a central bureau of information, providing information relative to the most reliable sources for help on any given topic, and the Chicago Academy of Sciences would naturally offer aid in the departments of Mollusca and ornithology. By this means the State Academy would become the recognized center around which the scientific activities of the various workers would crystallize.

In conclusion the speaker wishes to place before the State Academy for its consideration the subject of a biological survey of a size and nature commensurate with the extent and importance of the great state of Illinois.

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## FARM WATER SUPPLY.

EDWARD BARTOW.

Of the well waters sent to the State Water Survey during 1907, 60 per cent were condemned. Of the waters from wells less than twenty-five feet deep, 85 per cent. were condemned. Well water is usually sent to the Water Survey because of sus-

pected contamination. Therefore, believing that these well could not represent the normal well waters in the state, series of samples were collected from farms in five widely separated sections, namely, at Elgin, Kankakee, Champaign, Centralia, and Cairo. At Elgin deep rock wells predominate, and are in excellent condition. At Kankakee shallow rock wells predominate, and are in good condition. At Champaign, drift wells 160 feet deep are in the majority, and are in good condition. At Centralia, the shallow dug wells predominate and are poor. At Cairo, the samples were taken from cisterns, driven wells, and from one artesian well. The wells are in good condition.

Conclusions drawn from the examinations made, indicate that driven, drilled or bored wells can be obtained in many parts of the state, and are preferable. Where dug wells are necessary, as at Centralia, better precautions must be taken to prevent surface contamination.

# SYMPOSIUM ON THE ATMOSPHERE

## Opening Address by T. C. Chamberlin.

In opening the symposium Mr. Chamberlin dwelt chiefly on recent deductions relative to the distribution of atmospheric molecules outside of the recognized atmosphere and occupying in an attenuated way the remainder of the sphere of control of the earth. The basis of these deductions lies, in the main, in the accepted principles of the kinetic theory of gases, but the application of these principles is modified by sources of molecular agitation springing from radio-activity and electric dissociation. In the lower horizons of the familiar collisional atmosphere the molecules are held to move to and fro encountering one another some billions of times per second. They therefore pursue essentially straight paths at equal rates between encounters, because the interval is too short to permit gravity to curve their paths. But as we ascend to the upper regions of the collisional atmosphere the distances between encounters increase until at length the free paths are sufficiently long to be curved by gravity. At still greater heights curved paths come to dominate, and the spacing becomes so open that occasional molecules, rebounding outwardly from collisions, do not encounter any other molecules in their paths. In these cases the molecules go outward until the attraction of the earth stays their progress and starts a return movement toward the collisional atmosphere, which increases in velocity until an encounter takes

place. The principle remains the same whether the outshooting particle is directed normally or obliquely. In either case the molecule pursues theoretically an elliptical path. It is obvious that the more attenuated the atmosphere the more prevalent these escapes outward, followed by elliptical flights, must become. Gravity is the only barrier on the outer side and must ultimately take the place of collisions altogether in turning the molecules backward toward the earth. It is therefore inferred as a logical necessity that the outer face of the collisional atmosphere takes on this phase of action fully. Dr. Stone long since appropriately styled this phase of action, "fountain-like."

Logical analysis can not, however, stop here. The extent of the elliptical flight of any molecule is measured by the velocity it derived from the last encounter matched against the gravity of the earth. If the gravity overcomes the inertia of the molecule before it reaches the limit of the earth's control, it returns to the collisional atmosphere; if not, it passes beyond the sphere of the earth's control into that of the sun, and is lost, temporarily at least, to the atmosphere of the earth. Now under the Boltzmann-Maxwell law of distribution of velocities, some molecules must acquire velocities greater than the gravity of the earth can control. In addition to the velocities derived from the collisional atmosphere through the law of distribution, there are special agencies of agitation which give to some molecules of the external atmosphere exceptionally high velocities, and hence cause them to make excursions into the outer fields of the earth's control or pass entirely beyond it. Among these agencies are the impacts of meteorites, the ionizing action of ultra-violet light, the probable bombardment of the outer atmosphere by both electrons and alpha particles from the sun, the probable infall of molecules from the sun's atmosphere, the strokes of particles driven by light pressure, etc.

There does not, therefore, seem to be any bound which can be set as the outer limit of the earth's atmosphere of this class, except the limit of the earth's control. This limit of control on a line between the earth and the sun is, accordng to Moulton, 620,000 miles from the earth's center, and in the opposite direction, 930,000. These are the minimum and maximum radii of the spheroidal space within which the earth exercises greater differential attraction on molecules than the sun. This then may be taken as the strictest limitation of the earth's atmosphere.

Between the collisional atmosphere and this outer limit, the molecules in shooting out and returning are liable to collide with one another, and the rebounds from such encounters are liable to be in any direction. It therefore follows as a necessary consequence that if such a collision takes place when the velocities are of the higher order, and if the rebounds are more or less tangential to the earth's surface, one or both of the colliding molecules may pass into orbits about the earth, having such form that they will not encounter the collisional atmosphere. Inspection shows that of the molecules that have fallen back toward the earth a distance greater than its radius and which encounter molecules going outwards with like velocities, a notable percentage will pass into orbits instead of returning to the earth. This leads to the conception of an atmosphere formed of molecules that behave as satellites of the earth and are divorced, for the time being, from the collisional system and from the fountain-like system. It is important to observe further that this divorce lasts as long as the revolutional molecule escapes further encounter, and so, if we assume that the number of these is small, we at the same time impliedly assume that they have an excellent chance of remaining for long periods. This implies that the accumulation of such molecules may go on for

correspondingly long periods if the accumulation is not rapid. Hence, although the accessions be few in any brief period the final accumulation may be relatively great. When it is considered that the outer field within the earth's control which might be traversed by such orbital molecules is 20,000,000 times as great as that which is occupied by the collisional atmosphere, it will be seen that the total mass of orbital molecules might be considerable though the density remained very small.

It will be observed that we have assigned to this large outer field of the earth's control, two sets of moving molecules: the fountain-like system of outshooting-returning molecules, and the orbital system. The molecules of these two systems cut one another roughly at right angles, and collision between them is a necessary consequence. The logic of the case seems to drive us to the conclusion that the collisions between the outshooting and infalling molecules of the fountain-like system, among themselves, will divert into the orbital system molecules until such numbers accumulate in orbital courses that as many of these latter are thrown out of their orbits by collisions with one another or with the outshooting-infalling molecules as are thrown into the system by the latter. In other words, we seem forced to recognize a self-imposed limit which marks a state of equilibrium between the systems, after which as many orbital molecules, roundly, will be thrown back into the collisional system, or outside the control of the earth, as are thrown into the orbital system. Similar relations of equilibrium will be established mutually between all of the three systems.

We have thus far ignored the rotation of the earth. As the atmosphere is carried with the earth the molecules in the outer part of the equatorial atmosphere are moving from west to east at a rate, roundly, of 1,000 miles per hour faster than the molecules at the poles. It follows from this that, of the molecules

that are shot out from the equatorial belt, those directed eastward have the advantage of a rotational speed of 1,000 miles per hour, while those inclined to the westward have an equal disadvantage, a total difference of 2,000 miles per hour. Under these conditions molecules shot eastward will more largely pass into orbits than those shot against the rotation of the earth. It is therefore inferred that the orbital molecules of the equatorial tract moving in harmony with the earth's rotation will preponderate over those moving in the opposite direction, and that there will be a larger number of these than of any other class of orbital molecules. This view is strengthened by the fact that the influences agitating the molecules in the equatorial tract are more intense than those in higher latitudes. The earth is therefore conceived to be surrounded by a belt of molecular satellites revolving in the same direction as itself and having orbits at various distances from it out to the limit of control.

What may be the quantitative value of these rare supplementary atmospheres is not here estimated. It is difficult to determine from present data. There are suggestions that these atmospheres have some appreciable value, in the great heights at which meteorites become incandescent from atmospheric impact and friction, and in the still greater heights to which the aurora extends. Its streamers are held to be incandescent molecules whose light springs from their ionization. Trigonometrical measurements give them heights reaching to 600 and even 1,000 km.

The profound function which the atmosphere plays in both the organic and physical kingdom of the earth are thought to be sufficient justification for tracing out its factors to any degree of refinement and for using logical deductions where direct observation is impracticable.

## Discussion.

A. P. Carman spoke of the kinetic theory of gases and the mathematical assumptions made when we go beyond the very simple applications of that theory. The discussion of the escape of gas molecules from the earth's atmosphere involves assumptions of the rate of fall of temperature with height in the atmosphere. Extended experimental data on that subject are limited to a few stations, and then to a height of only two or three miles. The theory also calls for a change in the composition of the atmosphere as we go onward. The diagrams of Henrich and of Ferrel based on the dynamical theory of gases show that at comparatively small heights the percentage of the lighter gases of the atmosphere should increase measurably; and yet an observation at nine miles is on record, which shows no difference in the percentage of composition of the air at that height from the earth's surface. This can of course be explained as due to the mixture of the different atmospheric layers by currents; but it leaves us without confirmatory experiments. The rate of escape of the lighter gases from the earth's atmosphere, even according to mathematical physicists who allow that it can take place at all, is very small. Much data are therefore needed before we can speak with any great confidence of what takes place at the outer layers of the earth's atmosphere.

John M. Coulter said:

In considering the adjustment of plants to the present atmosphere, it is interesting to remember that there are plants existing, notably among the bacteria, which can live without free oxygen, which can manufacture carbohydrate food without chlorophyll or light, which can use free nitrogen, and which are remarkably resistant to external conditions that destroy other plants. This is suggestive of the possibilities of plant life under

conditions that would forbid all existing vegetation. It is an open question whether the plants referred to are survivors of an earlier vegetation under different atmospheric conditions, or have developed these remarkable habits under existing conditions. At all events, they teach us that the atmospheric conditions which would permit plant life are not necessarily those that obtain now.

In reply to a question, W. A. Noyes spoke of the recent demonstration by Cady and McFarland, of Kansas University, that helium is a practically universal constituent of natural gas and hence must be present in the atmosphere; also of the fact that the presence of helium in natural gas indicates a wide distribution of radium, and has an important bearing, especially in connection with the experiments of Strutt, upon the question of the source of heat in the interior of the earth.

In reply to another question, he also spoke of the two directions in which there is, at present, some prospect of rendering the nitrogen of the air available for use as a fertilizer and in other directions, namely, in the manufacture of calcium cyanamide and in the manufacture of nitrates by oxidizing the nitrogen of the air in an electric arc.

C. E. M. Fischer: The maintainance of a pure atmosphere is an economic question of great importance, affecting as it does the health and life of the community.

Chemistry teaches us of what a pure atmosphere consists, and also informs us of the various inanimate impurities which are contained therein at various times and places. Biology tells us of the various plant and animal spores with which the atmosphere is laden.

Medical science owes it as a duty to the community to make use of the facts taught by chemistry and biology to bring about

a pure state of the atmosphere by insisting that the same shall not be contaminated more than is unavoidable by dust of various kinds or noxious or poisonous gases and vapors originating in processes of manufacture, or by the careless introduction of disease germs therein.

The harm done by inanimate impurities consists not only of the diseases which they produce of themselves, but also of the lowering of body resistance with a consequent greater susceptibility to other diseases.

An individual whose lungs are continually being filled with the carbon particles of smoke, with particles of chalk dust, marble dust or the dust of metals, whose lungs and bronchi are continually being irritated by vapors of putrefaction, fumes from a laboratory, etc., whose blood is continually absorbing the gases of incomplete combustion, has very poor opportunity to become the oldest inhabitant. The germs of tuberculosis and pneumonia, to say nothing of the rest of the microbe family, mark him as an easy victim.

One of the most important of the animate impurities is the *Bacillus tuberculosis*. Rigidly *enforced* anti-spitting laws which will prevent the consumptive from depositing his daily contribution of 7,200,000,000 tuberle germs upon the sidewalk, later to be tdried and carried by the atmosphere thru a radius of many miles, will do much to decrease the yearly death rate from this disease, which in Illinois alone carried off over 7,000 inhabitants in 1907, and more than 150,000 in the whole United States.

Rigid quarantine of such diseases as scarlet fever and smallpox must also be here considered. That the atmosphere is important in their distribution is demonstrated by the fact that new cases often arise in the direction towards which the wind was blowing from improperly quarantined infected premises.

However, the province of the physician does not stop here. After seeing that a pure atmosphere is provided, he must see that the individual is able to make the fullest use thereof. No one realizes this more than the physician who has much practice among children.

It is a lamentable fact that many children, otherwise well cared for, are allowed to suffer from lack of sufficient air because of some nasal or pharyngeal defect whereby free respiration is interfered with. The importance of correcting such common defects as enlarged tonsils, adenoid growth, deformities and growths within the nose is a matter all too little appreciated by the laity, and countless children are left to suffer the effects of neglect of these conditions, never attaining their full mental or physical development in consequence thereof.

# ADDRESS

## RECENT ADVANCES IN SPECTROSCOPY.*

A. A. MICHELSON.

The fame of Newton rests chiefly on his epoch-making discovery of the laws of gravitational astronomy—by means of which the positions of the moons, the planets, and the comets, and other members of our solar system can be calculated and verified with the utmost precision, and in many cases such calculation and verification may be extended to systems of suns and planets outside our own.

But in no less degree are we indebted to this monumental genius for that equally important branch of astrophysics—in which the spectroscope plays so fundamental a role—by means of which we are enabled to discover the physical and chemical constitution of the heavenly bodies, as well as their positions and motions. As the number and intricacy of the wonderful systems of stellar worlds which the telescope can reveal increase with its power, so also do the evidences of the innermost molecular structure of matter increase with the power of the spectroscope. If Newton's fundamental experiment of separating the colors of sunlight had been made under conditions so slightly different from those in his actual experiment that in the present stage of experimental science they would at once suggest themselves to the veriest tyro, the science of spectroscopy would have been founded.

*Nobel Lecture, delivered by A. A. Michelson before the Royal Academy of Science at Stockholm, Dec. 12, 1907, and awarded the Nobel Prize.

So simple a matter as the narrowing of the aperture through which the sunlight streamed before it fell upon the prism which separates it into its constituent colors, would have sufficed to show that the spectrum was crossed by dark lines, named, after their discoverer, the Fraunhofer lines of the solar spectrum. These may be readily enough observed, with no other appliances than a slit in a shutter which is observed through an ordinary prism of glass. Fraunhofer increased the power of the combination enormously by observing with a telescope, and this simple combination, omitting minor details, constitutes that wonder of modern science, the spectroscope. As the power of a telescope is measured by the closeness of double stars which it can "resolve," so that of the spectroscope may be estimated by the closeness of the spectral lines which it can separate. In order to form an idea of the advance in the power of spectroscopes let us for a moment consider the map of the solar spectrum. (Fig. 1) * * (For Fig. 1 see colored plate in a good text-book of physics or an encyclopedia. Ed.)

The portion which is visible to the unaided eye extends from the Fraunhofer line A to H; but by photography it may be traced far into the ultra-violet region and by bolometric measurements it is found to extend enormously farther in the region beyond the red. In the yellow we observe a dark line, mark D, which coincides in position with the bright light emitted by sodium—as when salt is placed in an alcohol flame. It may be readily shown by a prism of very moderate power that this line is double, and as the power of the instrument increases, the distance apart, or separation, of this doublet furnishes a very convenient measure of its separating or revolving power. Of course this separation may be effected by simple magnification, but this would in itself be of no service, as the "lines" themselves would be broadened by the magnification in the same

proportion. It can be shown that the effective resolving power depends on the material of the prism, which must be as highly dispersive as possible, and on the size, or number, of the prisms employed; and by increasing these it has been found possible to "resolve" double lines thirty or forty times as near together as are the sodium lines. It will be convenient to take the measure of the resolving power when just sufficient to separate the sodium lines as 1,000. Then the limit of resolving power of prism spectroscopes may be said not much to exceed 40,000.*

This value of resolving power is found in practice to obtain under average conditions. Theoretically there is no limit save that imposed by the optical conditions to be fulfilled—and especially by the difficulty in obtaining large masses of the refracting material of sufficient homogeneity and high dispersive power. It is very likely that this limit has not yet been reached.

Meanwhile another device for analysing light into its component parts has been found by Fraunhofer †, which at present has practically superseded the prism; namely, the diffraction grating. Fraunhofer's original grating consisted of a number of fine equidistant wires, but he afterwards made them by ruling fine lines on a glass plate covered with gold-leaf and removing the alternate strips. They are now made by ruling upon a glass or a metal surface fine equidistant lines with a diamond point.

The separation of light into its elements by a grating depends on its action on the constituent light-waves.

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*Lord Rayleigh has obtained results from prism of carbon disulphide which promises a much higher resolving power.

†1821.

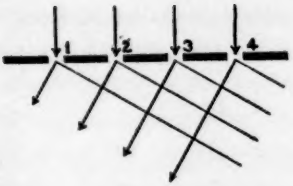


Fig. 2.

Let Fig. 2 represent a highly magnified cross-section of a diffraction grating with plane waves of light falling upon it normally, as indicated by the arrows. The wave motion will pass through the apertures, and will continue as a series of plane waves; and if brought to a focus by a telescope will produce an image of the slit source just as if no grating were present (save that it is fainter, and some of the light is cut off by the opaque portions). This image may be considered as produced by the concurrence of all the elementary waves from the separate apertures meeting in the same phase of vibration, thus re-inforcing each other. But this may also be true in an oblique direction, as shown in the figure, if the retardation of the successive waves is just one whole wave length (or any whole number), as is illustrated in Fig. 3,

Fig. 3.

where the successive waves from apertures 1, 2, 3, are shown to re-inforce each other just as if they all belonged to a single

wave- train. In this direction therefore there will also be an image of the slit source; and this direction is determined by the relation

$$\sin \Theta = \frac{ml}{s}$$

where $l$ is the length of the light-wave of this particular color; $s$, the distance between the apertures (the grating space); and $m$, the number of waves in the common retardation (1, 2, 3, etc.) But even if the light thus diffracted be absolutely homogeneous (that is, consist of an infinite wave-train of constant wave-length) it does not follow that the light is diffracted in the given direction; there will be some light in directions differing slightly from this—growing less until the extreme difference of path is, say, n+1 waves (instead of n), when it is nil.

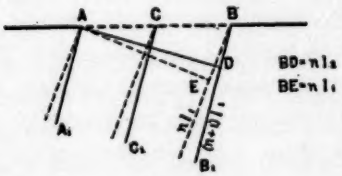


Fig. 4.

In fact, if we divide the pencil having this new direction into two equal parts, AC and CB, the ray AA, will be n+½ waves in advance of CC, and the two will be in opposite phases of vibration and will therefore neutralize each other. The same will be true of each pair of rays taken in the same manner over the whole grating space, and the result is total darkness for this direction. Let us suppose we are examining the double sodium line. The difference between the components is about one-thousandth of the wave length. With a grating of n lines there will

be total darkness in a direction corresponding to a retardation of $(n+1)l_1$. Let this direction correspond to the brightest part of the image for the second sodium line $l_2$, so that $(n+1)l_1=nl_2$, or $l_2-l_1=\frac{l_1}{n}$. Under these conditions the two images are just "resolved." But $\frac{l_2-l_1}{l_1}=\frac{1}{1000}$ for sodium lines, whence n=1000. That is a grating of 1000 lines will "resolve" the sodium lines in the spectrum, or R=1000. In the second (where the common retardation is two waves lengths) the resolving power is twice as great, or $2n$, and in the $mth$ spectrum, $xm$ times as great. The resolving power is therefore the product of the number of lines in the grating by the order of the spectrum, that is, $R=mn$

In order, therefore, to obtain high resolving power the grating must have a large number of rulings, and if possible a high order of spectrum should be used. The rulings need not be exceedingly close together, but it is found practically sufficient if there are from 500 to 1000 lines per millimeter. The earlier gratings were relatively small and contained only a few thousand lines. The best of these were ruled by Nobert, (1851). A very great advance was made by Rutherford, of New York, who, in 1868, ruled gratings two inches long, on speculum metal and containing about 20,000 lines. These gratings exceeded in resolving power the best prism-trains in use at the time. The next advance was made by Rowland, of the Johns Hopkins University, who succeeded in ruling gratings six inches long (by two to three inches stroke) having about one hundred thousand lines, and capable (theoretically, at least) of resolving in the first spectrum, double lines whose distance apart was only one one-hundredth as great as that of the sodium lines. Practically this is about the limit of the power of the best Rowland grating which I have examined.

The difference between the theoretical and the actual per-

formance is due to want of absolute uniformity in the grating space. This is due to the enormous difficulty in constructing a screw which shall be practically perfect throughout its whole length—a difficulty which increases very rapidly as the length of the screw increases, and it has been supposed that the limit of accuracy was reached in these gratings.

The great and rapidly increasing importance of spectrum analysis, especially in determining the distribution of light in so-called spectral lines under normal conditions, in the resolution of complicated systems of lines, and in the investigation of the effects of temperature, of pressure, and especially of a magnetic field, justified the undertaking of much larger gratings than these. As an example of progress made in this direction, I have the honor of exhibiting a grating having a ruled surface nine inches long by four and one-half inches stroke (220mm× 110mm.) This has one hundred and ten thousand lines and is nearly perfect in the second order, so that its resolving power is theoretically 220,000, and is very nearly realized in actual experiments.

It will be observed that the effect produced at the focus of the telescope depends on the concurrence or opposition—in general on the *interference*—of the elementary trains of light-waves. We are again indebted to the genius of Newton for the first observation of such interference; and a comparatively slight modification of the celebrated experiment of "Newton's rings" leads to a third method of spectrum analysis which, if more indirect and less convenient than the methods just described, is far more powerful. If two plane surfaces (say the inner surfaces of two glass plates) are adjusted very accurately to parallelism, and sodium light fall on the combination at nearly normal incidence, the light reflected from the two surfaces will interfere, showing a series of concentric rings alternately bright

and dark, according to the relative retardation of the two reflected light-beams.

If this retardation change (by slowly increasing the distance between the surfaces(, the center of the ring system goes through alternations of light and darkness, the number of these alternations corresponding exactly to the number of light-waves in twice the increase in distance. Hence the measurement of the length of the waves of any monochromatic light may be obtained by counting the number of such alternations in a given distance. Such measurements of wave lengths constitutes one of the most important objects of spectroscopic research.

Another object accomplished by such measurement is the establishment of a natural standard of length in place of the arbitrary standard at present in use—the meter. Originally it was intended this should be the ten-millionth part of an earth-quadrant, but it was found that the results of measurements differed so much that this definition was abandoned. The proposition to make the ultimate standard the length of a pendulum which vibrates seconds at Paris met with a similar fate.

Shortly after the excellent gratings made by Rutherford appeared, it was proposed (by Dr. B. A. Gould) to make the length of a wave of sodium light the ultimate standard; but this idea was never carried out. It can be shown also that it is not susceptible of the requisite degree of accuracy, and in fact a number of measurements made with a Rowland grating have been shown to be in error by about one part in thirty thousand. But modern conditions require a much higher degree of accuracy. In fact, it is doubtful if any natural standard could replace the arbitrary standard meter, unless it can be shown that it admits of realization in the shape of a material standard which can not be distinguished from the original.

One of the most serious difficulties encountered in the at-

tempt to carry into practice the method of counting the alternations of light and darkness in the interference method, is the defect in homogeneity of the light employed. This causes indistinctness of the interference rings when the distance is greater than a few centimeters. The light emitted by various kinds of gases and metallic vapors, when made luminous by the electric discharge, differs enormously in this respect. A systematic search showed that among some forty, or more, radiations nearly all were defective, some being represented by a spectrum of broad hazy "lines," others being double, triple, or even more highly complex. But the red light emitted by luminous vapor of metallic cadmium was found to be almost ideally adapted for the purpose. Accordingly this was employed; and the results of three independent measurements, made by different observers and at different times, of the number of light-waves of red cadmium light in the standard meter are as follows:

I. 1553392.4.
II. 1553393.2.
III. 1553393.4.

It will be seen that the differences are less than half a millionth part, and this is about the limit of accuracy of the comparative measurements of the material standards. Within the last year a similar determination has been carried out by Perot and Fabry, with a result not to be distinguished from the above. It fellows that we now have a natural standard of length—the length of a light-wave of incandescent cadmium vapor—by means of which a material standard can be realized, whose length can not be distinguished from the actual standard meter,—so that if, through accident or in time, the actual standard meter should alter, or if it were lost or destroyed, it could be replaced so accurately that the difference could not be observed.

In the search for a radiation sufficiently homogeneous for

the purpose of a standard, it became evident that the interference method might be made to yield information concerning the distribution of light in an approximately homogeneous source when such observations would be entirely beyond the power of the best spectroscopes. To illustrate, suppose this source to be again the double radiation from sodium vapor. As the wave lengths of these two radiations differ by about one part in a thousand, then at a difference of path of five hundred waves (about 0.36 mm.) the bright fringes of one wave-train would cover the dark fringes of the other, so that if the two radiations were of equal intensity all traces of interference would vanish. At twice this distance they would reappear, and so on indefinitely, if the separate radiations were absolutely homogeneous. As this is not the case, however, there would be a gradual falling off in the clearness or visibility of the bands. Inversely, if such changes are observed in actual experiment, we infer that we are dealing with a double source. Further, from the distance between the maxima of distinctions, we may determine (and with extraordinary accuracy) the ratio of wave lengths of the components; from the ratio of maxima to minima we may infer the ratio of their intensities; and, finally, the gradual falling off when the distance becomes large gives accurate information of the "width" of the corresponding spectral lines.

In this way it was found that the red line of hydrogen is a double with components about one-fortieth of the distance apart of the sodium lines. Thallium has a brilliant green radiation which is also double, the distance being one-sixtieth that of the sodium lines. Mercury shows a brilliant green line, which is highly complex, but whose chief component is a doublet, whose separation is only one seven-hundredth of that of sodium. The interference fringes are still visible when the difference of path is of the order of five hundred millimetrs, corrsponding to

over a million light-waves;; and the corresponding width of spectral line would be less than a thousandth part of that which separates the sodium lines.

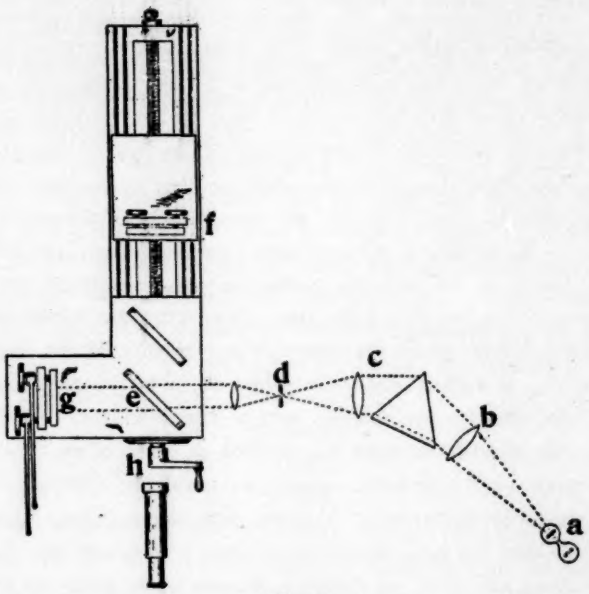


Fig 5.

Figure 5 illustrates the arrangement of the apparatus as it is actually used. An ordinary prism spectroscope gives a preliminary analysis of the light from the source. This is necessary because the spectra of most substances consist of numerous lines. For example, the spectrum of mercury contains two yellow lines, a very brilliant green line, and a less brilliant violet line, so that if we pass all the light together into the interferometer, we have a combination of all four. It is usually better to separate the various radiations before they enter the interferometer.

Accordingly, the light from the vacuum tube at *a* passes through an ordinary spectroscope *bc*, and the light from only one of the lines in the spectrum thus formed is allowed to pass through the slit *d* into the interferometer.

As explained above, the light divides at the plate *e*, part going to the mirror *f*, which is movable, and part passing through, to the mirror *g*. The first ray returns on the path *feh*. The second returns to *e*, is reflected, and passes into the telescope *h*.

The resolving power of the interferometer is measured by the number of light-waves in the difference of path of the two interfering pencils, and as this is unlimited, the interferometer furnishes the most powerful means for investigating the structure of spectral lines or groups. Its use is, however, somewhat handicapped by the fact that the examination of a single group of lines may require a considerable number of observations which take some time and during which it may be difficult to prevent changes in the light source. Nevertheless it was found possible by its means to investigate the wonderful discovery of Zeeman—of the effect of a magnetic field on the character of the radiation from a source subjected to its influence—and the results thus obtained have been confirmed by methods subsequently devised.

One of these is the application of the echelon. This is in effect a diffraction grating in which high resolving power is obtained by using a very high order of spectrum into which practically all the light is concentrated. The number of elements may be quite moderate—since the resolving power is the product of the two. The order of the spectrum is the number of wave lengths in the retardation at each step. This retardation (which must be very accurately constant) is secured by allowing the incident light to fall upon a pile of glass plates optically plane

parallel and of the same thickness—each one a little wider than the preceding as in Fig. 6.

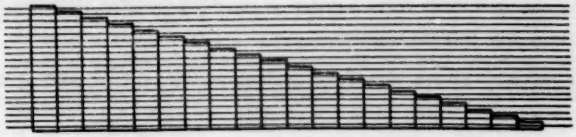

Fig. 6.

Thus, if the pile has forty plates, each one centimeter thick, the retardation will be about ten thousand light-waves; and the revolving power would be forty times this, or four hundred thousand—which is about four times as great as that of a six-inch diffraction grating of the usual form. The number of elements might be increased till the absorption of the glass brought a limit. A difficulty, which appears long before this limit is reached, is due to the loss of light by repeated reflections between the many surfaces. This has been very ingeniously overcome by Mr. Twyman, of the firm of Hilger & Company, by pressing the plates tigether to actual contact, when the reflection vanishes. It is likely that the echelon under these conditions may be used by reflection instead of transmission (the plates being silvered for the purpose) with the advantage of quadrupling the resolving power for the same number of plates and eliminating the absorption.

An illustration of the efficiency of the echelon spectroscope is furnished by the following photographs of the spectrum of green radiations from mercury vapor. The first of the figures shows the spectrum of the second order of a diffraction grating whose ruled surface is nine inches by four and a half—the largest in existence. The second is by an echelon of thirty plates, each an inch and a fourth think (30 mm). The corresponding lines are similarly lettered in the three figures. The

scale is in Aongstrom unites. It will be noted in the last of the three figures that the width of the fainter companion is about one one-hundredth of an A. U. The limit of resolution of the instrument is about half as much, or its resolving power is over a million. (Figs. 7, 8, 9, Plates I and II.)†

It will be observed that the echelon spectra are repeated, thus, $a_1$ and $a_2$ are two successive spectra of the same line. This is true of any grating spectrum, and the difficulties which arise from the overlapping of the successive orders of spectrum may be overcome by separating these by a prism whose refracting edges are perpendicular to the lines of the grating. The same is true of the echelon spectrum—save that the order of the overlapping spectra is so high that a prism is hardly adequate, and recourse must be had to a grating with its plane of diffraction perpendicular to that of the echelon.

With this arrangement it is possible to photograph a large part of the spectrum at once.*

A photograph of the iron spectrum may be taken so that it may be noted that this combination of grating and echelon makes it possible to observe absorption spectra as well as bright line spectra.

A photograph of the solar spectrum may be so taken as to show that the spectral "lines" are generally too broad to justify the use of so great a resolving power.

Finally it may be pointed out that this combination gives us the means of comparing the wave lengths of spectral lines with a degree of accuracy far superior to that of the grating.

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†For these illustrations see Michelson's paper as originally published.

*If the preliminary analysis has been made before the light entered the slit of echelon spectroscope, it would be possible to examine but one—at most a few—lines at a time.

# COUNCIL MEETING

OF

## STATE ACADEMY OF SCIENCE.

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## AUDITORIUM ANNEX.

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CHICAGO, ILL., FRIDAY, MAY 8, 2:30 P. M.

On motion of Prof. Crew the following committee upon the ecological survey of the State of Illinois was appointed: S. A. Forbes, Chairman; F. C. Baker, H. C. Cowles, H. A. Gleason, F. T. L. Hankinson.

It was voted to publish an 8vo volume of "Transactions" which should include the transactions of the meeting of organization and of the first regular meeting, the constitution, and the list of members.

It was voted to hold the next meeting of the Academy at Springfield, February 20, 1909, at which meeting the program shall consist of a business meeting and reading of papers in the morning, a symposium on the scientific activities of the State—their history, methods and purpose—in the afternoon, and an address by the retiring president in the evening.

The Council then adjourned.

A. R. CROOK, *Secretary.*

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